Surface Water Monitoring and Assessment 1997 Lake Ontario Report

Featuring a Summary of Tributary and Nearshore Conditions and Trends for the Lake Ontario Basin

November 1999

Ontario

Ministry of the Environment

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135 St. Clair Avenue West
Toronto ON M4V 1P5

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Ontario

May 31, 2000

MEMORANDUM

To: All ESSD and OD Directors

From: E. Piché
Director
Environmental Monitoring and Reporting Branch

Subject: Surface Water 1997 Lake Ontario Report

I am pleased to forward to you the first annual EMRB Great Lakes Report: *1997 Lake Ontario Report*. This is the first in a series of annual reports to be issued by EMRB based on the lake-by-lake survey strategy adopted by MOE in 1997. The 1998 Lake Erie Report and the 1999 Lake Superior Report will follow. The upper Lakes (Superior and Huron) are monitored every six years and the lower lakes (Erie and Ontario) are assessed every three years.

Please do not hesitate to contact my office if you require any additional information or if you have any questions or comments on our new reporting strategy. Please note that the report can also be found on the Ministry's website, document # 3933 in six parts at: http://www.ene.gov.on.ca/envision/techdocs/index.htm.

E. Piché

cc: J. MacLean
F. Fleischer
D. Boyd

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Prepared by:
Environmental Monitoring and Reporting Branch

November 1999

Cette publication technique
n'est disponible qu'en anglais.

Printed on 50% recycled paper including 10% post-consumer fibre

ISBN 0-7778-9531-5

PIBS 3933E

Foreword

The *Surface Water Monitoring and Assessment 1997 Lake Ontario Report* has been prepared to summarize the range of recent surface water monitoring work undertaken by the Environmental Monitoring and Reporting Branch. The introductory material provides an overview of the various programs supported by the Branch and is followed by a summary of selected recent water quality results and trends. Lake Ontario was the focus of 1997/98 ambient monitoring in the Great Lakes, and consequently this Annual Report highlights results from Lake Ontario tributary and nearshore monitoring. Subsequent Annual Reports will focus on different Lake Basins according to the lake-by-lake monitoring cycle described in this document.

The initial overview is intended to provide program managers within the Ministry, as well as other Provincial and Federal agencies, with basic information concerning the current surface water monitoring database and mandate of the Branch. The summary of selected data is provided to illustrate the range of information available to anyone interested in water quality issues. The intention is to allow interested readers to pursue details pertaining to their particular area of interest, whether they represent provincial, federal, or municipal agencies, universities, or consultants. By making this summary widely available we are also endeavouring to improve access to technical information and staff within the Branch. Given the wide range of environmental issues and challenges in the Great Lakes Basin, such access is essential for internal and external program coordination, and the provision of timely and effective client services.

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1.0 Surface Water Monitoring Program Summary

As described in the MOE Business Plan, the provincial commitment to Environmental Protection includes *"Improving Water Quality"* as a Core Business goal. The Ministry's surface water quality management goals associated with this Core Business are to ensure that (a) the quality of surface water is protected to ensure a healthy aquatic ecosystem; and (b) drinking water supplies are safe and aesthetically pleasing. Surface water quality management in Ontario is guided by a range of policies which outline the manner in which the Ministry will apply and enforce the appropriate aspects of environmental legislation (including the Environmental Protection Act, Ontario Water Resources Act, and the Environmental Assessment Act). Three of these policies are directly applicable to water quality monitoring:

> <u>Policy 1:</u>
> *In areas which have water quality better than Provincial Water Quality Objectives (PWQOs), water quality shall be maintained at or above the* Objectives;
>
> <u>Policy 2:</u>
> *Water Quality which presently does not meet the PWQOs will not be degraded further and all practical measures will be taken to upgrade the water quality to the Objectives*; and
>
> <u>Policy 5:</u>
> *Mixing zones [areas contiguous to a pollution source where the water quality fails to comply with one or more of the PWQOs] should be as small as possible and not interfere with beneficial uses. Mixing zones are not to be used as an alternative to reasonable and practical treatment.*

These Policies require an understanding of the prevailing water quality status as the basis for regulatory decisions (e.g. issuance of a Certificate of Approval). In addition to these policies, the Ministry publication *Deriving Receiving-Water Based, Point-Source Effluent Requirements for Ontario Waters* stresses the importance of background physical, chemical, and biological conditions in developing receiving-water based effluent requirements.

The current surface water ambient monitoring program administered by the Environmental Monitoring and Reporting Branch (EMRB) includes three general components: River Systems Monitoring and Assessment, Great Lakes Nearshore Monitoring and Assessment, and Inland Lake Monitoring (which is undertaken in partnership with Cottagers Associations through the Lake Partner Program and is reported separately).

1.1 River Systems Monitoring and Assessment

The River Systems Monitoring and Assessment Program provides measurement and assessment of water quality and stream flow in rivers and streams throughout Ontario. Water quality and flow information is used to track long term (>20 years) and recent trends, to map spatial patterns across watersheds with differing land-use characteristics, and for the environmental planning and approvals process.

The core program includes the following:

1.1.1 Provincial Water Quality Monitoring Network (PWQMN)

Water quality sample collections are undertaken across the province at approximately 200 sites in partnership with MOE Regional Technical Assessment Units and local Conservation Authorities. Samples are currently collected at approximately monthly intervals from April through November and are analysed for a range of water quality indicators (including temperature, pH, conductivity, turbidity, suspended solids, major ions, nutrients, and metals) in order to screen overall water quality and identify potentially anomalous results.

1.1.2 Enhanced Tributary Monitoring Program (ETMP)

Since 1980 samples have been collected near the mouths of 16 strategically chosen watersheds throughout the Great Lakes Basin representing approximately 50% of the total flow into the Great Lakes from Canadian watersheds. The program tracks long term changes in water quality and contaminant loadings. Currently, approximately 20 samples per year are collected at each station with an emphasis on the spring freshet which typically accounts for a significant proportion of annual contaminant loadings. Samples are analysed for the same parameters as the PWQMN samples with additional analysis for trace organics (e.g. PCBs and organochlorine pesticides, and other in-use pesticides at selected locations). Results from this program provide a means of assessing spatial and temporal trends in water quality and contaminant loadings among and within major watersheds, and allow the screening of potential "problem" watersheds. This activity also supports the Provincial commitment to the Great Lakes Water Quality Agreement (GLWQA) of the International Joint Commission (IJC).

1.1.3 Streamflow Network

Hydrometric data are fundamental to the information required by MOE for water quality assessments, pollutant loading computations, discharge approvals, issuing of *Permits to Take Water*, resolution of interference complaints, and policy and standards development. Presently there are about 325 stations in the Ontario network. A 1975 Agreement between Canada and Ontario regarding hydrometric surveys in the province includes MOE as a signatory. Environment Canada acts on behalf of the federal government as both a partner and operator of the network while the Ministry of Natural Resources is the major partner acting on behalf of the province of Ontario. The purpose of the agreement is to provide a coordinated, standardized and cost shared approach to the collection of streamflow data. Under the terms of the Agreement, the provision of partial annual funding for the operation and maintenance of the network gives MOE access to all collected hydrometric data.

1.2 Great Lakes Nearshsore Monitoring and Assessment Program

This program is designed to measure environmental indicators related to toxics, nutrients, microorganisms, and exotic species in the nearshore areas of the Great Lakes and connecting channels. It also provides assessments of site-specific environmental problems, and effectiveness of remedial and abatement activity in nearshore areas, harbours and embayments (including "Areas of Concern" identified to the International Joint Commission). In addition to meeting internal MOE information requirements, this program also supports the Provincial commitment to the Great Lakes Water Agreement of the International Joint Commission (as described through the Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem).

Core elements of ambient monitoring are undertaken on a lake-by-lake basis over a multi-year cycle so as to provide good spatial coverage of the Great Lakes while maintaining an acceptable level of sampling frequency for most data uses. A periodic sampling cycle that allows for a greater intensity of sampling in Lakes Ontario and Erie (the lake basins under greatest stress) is guiding the field schedule presently for most of the program elements. The current planned cycle is as follows:

Year	Lake Basin/Connecting Channel Unit
1997	Lake Ontario, St. Lawrence River, Niagara River
1998	Lake Erie, Detroit River, Lake St.Clair, St.Clair River
1999	Lake Superior, St. Marys River, North Channel
2000	Lake Ontario, St. Lawrence River, Niagara River
2001	Lake Erie, Detroit River, Lake St.Clair, St.Clair River
2002	Lake Huron, Georgian Bay

The core nearshore monitoring and assessment program includes the following elements:

1.2.1 Great Lakes Index Station Monitoring

"Index" and "reference" stations are located in areas representative of background conditions and in areas where there is a natural integration of the stressors from a larger area. Fifty-seven core sites *(see map)* have been established throughout the Great Lakes basin and a minimum of seven sites are visited within a lake basin each year according to the lake-by-lake cycle. This network of stations is designed to provide information on where and how water quality conditions are changing over time by periodically monitoring a suite of environmental indicators. Sampling is undertaken for summer concentrations of priority toxic contaminants in sediment and suspended particulate material as an indicator of the level of priority contaminants present in the aquatic environment. Summer species composition and abundance of benthic invertebrates are monitored as a biological indicator of overall ecosystem health and as a general stress response indicator. Spring, summer, and fall sampling is undertaken for various physical measurements including thermal and optical profiles of the water column, and physical characterization of the lake bottom as indicators of habitat integrity.

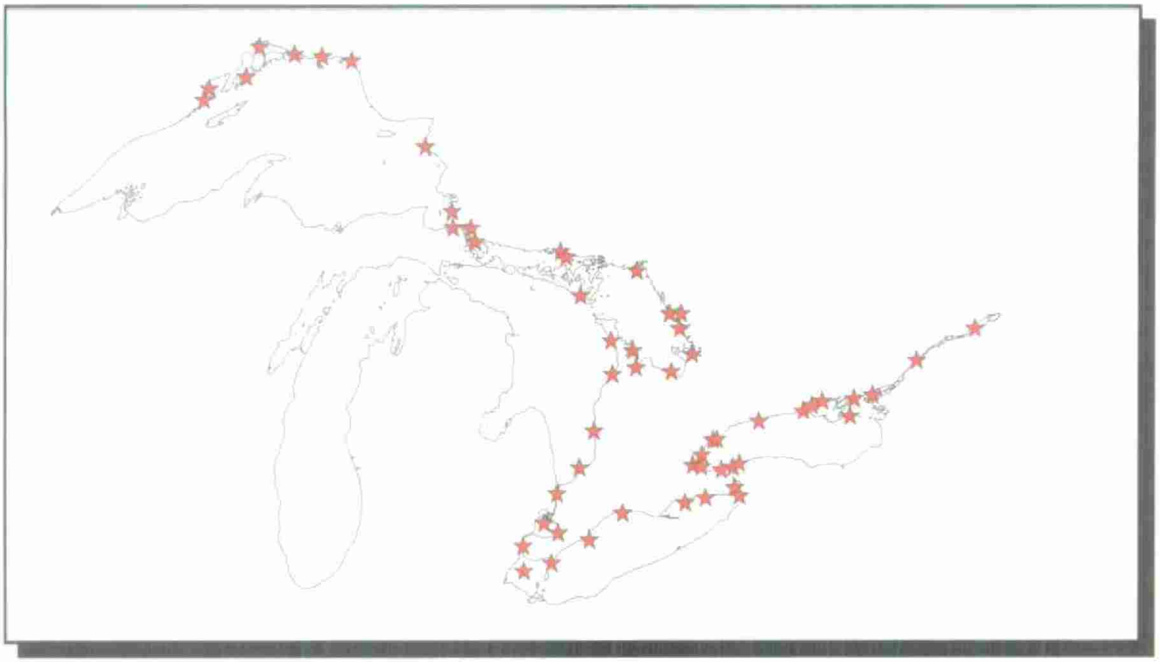

Figure 1.2.1: Index and Reference Monitoring Locations

1.2.2 Great Lakes Reconnaissance Monitoring
Reconnaissance monitoring is designed to identify the status of environmental indicators in the immediate nearshore zone most strongly and directly affected by land-based activities and is undertaken in two parts. The first involves "real-time" mapping of nutrient, bacteriological, physical and aesthetic features of water quality along selected ranges of shoreline. The second, Harbour Water Quality Screening, involves more extensive sampling at a limited number of key sites (frequently within the above survey areas) where water quality conditions at sites are known to be impacted, or, have a potential for impact. Additional sampling for trace contaminants and sediment quality is conducted at these stations to enable calculation of various water and sediment quality indices. Data are compared with Provincial Water Quality Objectives (PWQOs) and Provincial Sediment Quality Guidelines (PSQGs) to screen harbours and embayments (including those which have not been the traditional focus of attention by the IJC) for sources of pollutants such as municipal and industrial effluent discharges, and historical accumulations in sediment.

1.2.3 Great Lakes Toxics Biomonitoring
Long-term monitoring of contaminant levels in mussels, zebra mussels, juvenile fish, and selected sport fish is undertaken to track levels of toxic contaminants (i.e. persistent, bioaccumulative substances) through time across the Great Lakes. Sport fish results reflect the long-term, spatially integrated effects of exposure to persistent bioaccumulative substances (e.g. PCBs, dioxins/furans) and provide a superior means of tracking long-term trends over the basin as a whole. They also form the basis of the *Guide to Eating Ontario Sport Fish*. Mussel and juvenile fish data, on the other hand, provide a means of identifying problem zones and potential contaminant sources and assessing the corresponding long term trends.

1.2.4 Great Lakes Tributary Toxics Monitoring

This sampling is intended to identify those tributaries with significant concentrations and loadings of persistent bioaccumulative substances to each of the Great Lakes on an annual lake-by-lake cycle. A combination of biomonitoring, flow monitoring, and temporally integrated large-volume sampling for trace organics (PCB congeners, organochlorines, chlorobenzenes, PAHs), physical parameters, nutrients, and metals is employed.

1.2.5 Great Lakes Water Intake Biomonitoring

Water intake biomonitoring is undertaken to identify long term trends in nutrient status using year-round (weekly-monthly) nutrient concentrations and phytoplankton biomass as indicators. Monitoring has been ongoing for more than 20 years from raw intake water at 18 water treatment plants that draw water from the Great Lakes. Six of these are situated in Lake Ontario (see Map). Results are used to assess the effectiveness of nutrient management programs in the Great Lakes. A secondary benefit of this monitoring data is that it may provide an indication of effects from a variety of stressors not actively monitored in the aquatic environment (e.g. climate change).

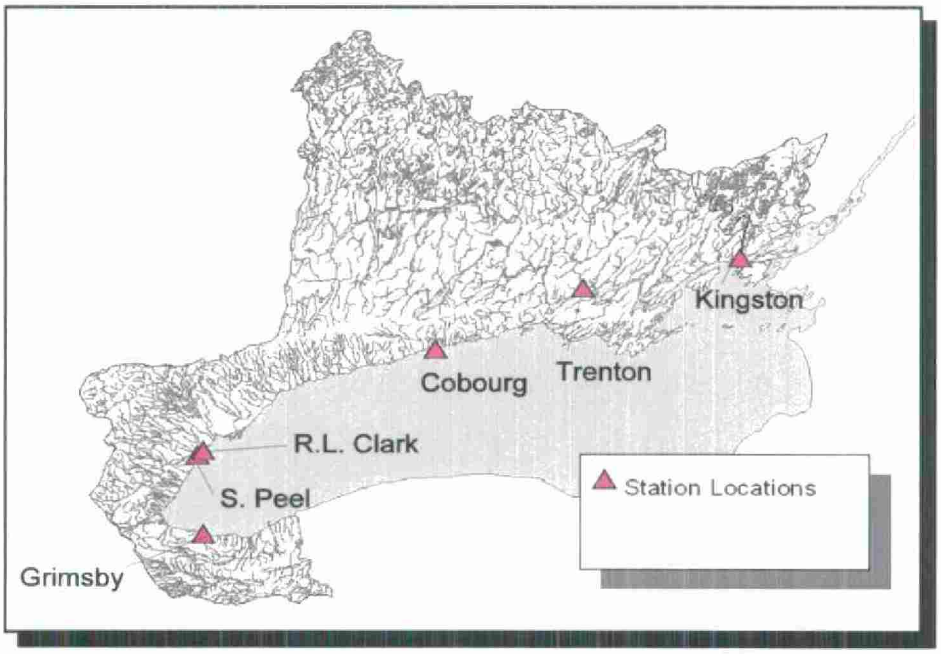

Figure 1.2.2: Water Intake Monitoring Locations in Lake Ontario

1.3 Investigations and External Services

There remains an ongoing need for a number of site/area assessment surveys specifically designed to examine the extent and nature of site-specific environmental impacts of known contaminant sources and other anthropogenic stressors. These investigative surveys are frequently undertaken at the request of Operations Division, often as part of the federal-provincial Remedial Action Plan program. These types of investigations are integrated with the core ambient monitoring activity survey schedule if this can be accomplished without compromising the quality of service to Operations Division. Otherwise, requests are dealt with case-by-case. Depending upon the nature and complexity of the work, results from these projects are reported in Technical Memoranda or more detailed reports. Examples of these investigations in recent years include:

Year(s)	Description
1995 and 1996	Toronto Sediment and Benthos Monitoring
1995 and 1996	Thunder Bay (Northern Wood Preservers) Investigation
1996	St. Clair River and Detroit River Juvenile Fish Monitoring
1996 and 1997	St. Lawrence River Juvenile Fish Monitoring
1996 - 1998	Niagara River Juvenile Fish Monitoring
1996 - 1998	Bay of Quinte Phytoplankton Investigation
1996 and 1997	Belleville Waterfront Sediment Investigation
1996 and 1997	Port Dalhousie Harbour Sediment and Biomonitoring Investigation
1996	Owen Sound Coal Tar Sediment Investigation
1996	St. Clair River, Dow Cleanup Monitoring
1996	Toronto Eastern Beaches Tank Monitoring
1996	Welland River Sediment and Benthic Investigation
1996	Port Dalhousie Sediment Investigation
1996 - 1998	Severn Sound Water Quality Analysis and Sediment Survey
1997	Cornwall Sediment Survey
1998	Wheatley Harbour RAP Survey
1998	LaCloche Channel Aquaculture Survey

2.0 Selected Results and Trends for Lake Ontario Tributary and Nearshore Water Quality Monitoring

2.1 Summary Description of Lake Ontario Basin

Lake Ontario is the last in the chain of Great Lakes and is the smallest Great Lake in terms of surface area (approximately 19,000 square kilometres) although its total volume of 1,640 cubic kilometres is over three times greater than that of Lake Erie. The average depth of the lake is 86 metres, with a maximum depth of 244 metres. About 93% of the lake's water flows out through the St. Lawrence River and another 7% is lost through evaporation. The average "residence time" for water in the lake is approximately six years.

Approximately 80% of the water flowing into Lake Ontario comes from Lake Erie via the Niagara River with the remaining flow coming from tributaries within the Lake Ontario watershed and from precipitation. This large contribution from Lake Erie and the upper lakes, relative to local sources, means that general water conditions in Lake Ontario for many conservative pollutants (typically those that are not biodegradable, volatilized to the air or partitioned into the sediment) such as dissolved solids, or contaminants associated with extremely small colloidal particles, are largely influenced by activities and trends outside the lake's local drainage basin.

With a watershed land area of approximately 64,000 square kilometres, Lake Ontario has the highest ratio of watershed land area to lake surface area of all the Great Lakes. Although the peripheral upland areas of the Lake Ontario basin are forested, nearer the lake, the basin's climate and soil types support various agricultural activities (areas such as the Niagara region are highly specialized for growing fruits and vegetables) and urban areas with high populations densities. The "Golden Horseshoe" extending from Cobourg in the east around the western end of Lake Ontario to St. Catharines and Niagara Falls is highly urbanized and industrialized and includes Metropolitan Toronto and the industrial centre of Hamilton.

Lake Ontario water is used as a drinking water supply by approximately 4.3 million Ontario residents, as well as for industrial and commercial uses. Lake Ontario supports a Canadian commercial fishery for Lake whitefish, American eel, Yellow perch, and Bullheads worth approximately $1.5 million (CDN). Recreational fishing is primarily for salmon and trout species in the open lake and tributaries; walleye in the eastern part of Lake Ontario and smaller numbers of perch, smallmouth bass and panfish in the embayments. The economic value of the recreational fishery to local communities is estimated to exceed $100 million per year.

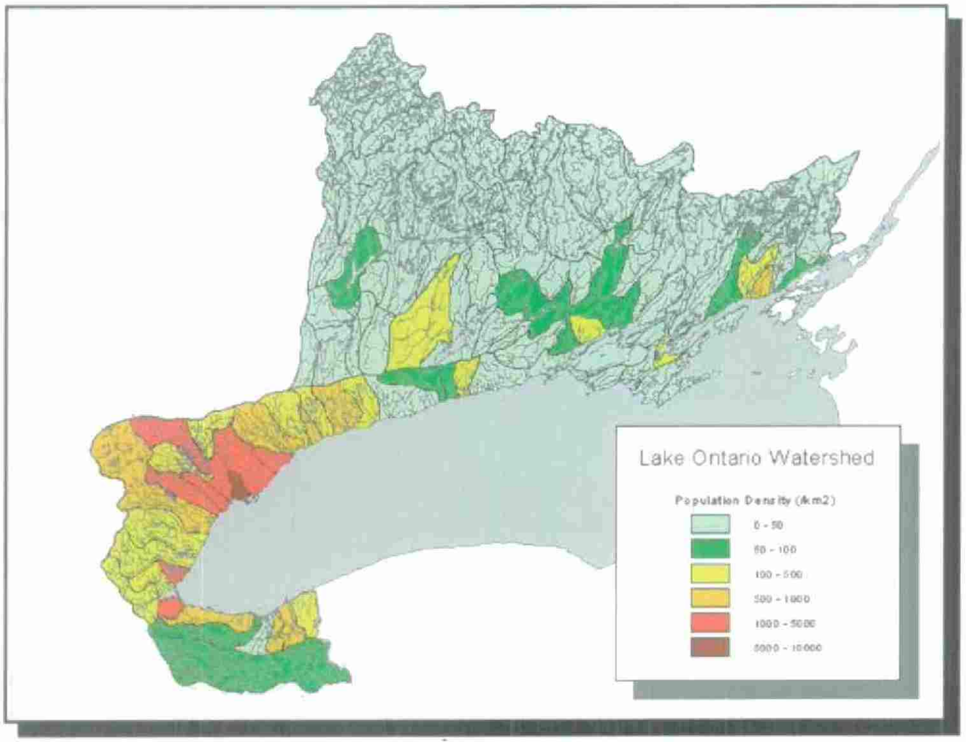

Figure 2.1.1: Population Densities in the Lake Ontario Drainage Basin

2.2 Land Use, Pollution Sources, and Selection of Water Quality, Sediment Quality, and Biomonitoring Indicators

2.2.1 Land Use and Pollution Sources

The extensive urban/industrial and rural/agricultural land use activity within the Lake Ontario drainage basin of accounts for a range of pollutants entering tributaries and lakes from "point sources" (e.g. industrial and municipal effluent discharges) and "non-point sources" (e.g. diffuse runoff from urban or agricultural areas). These pollutants include suspended solids, dissolved solids, bacteria, nutrients, metals, and trace organic contaminants (including pesticides, PCBs, and a range of industrial organic chemical byproducts). Associated impacts can range from short-term restrictions on recreational water use, to impaired aquatic and benthic habitat, to uptake and magnification of persistent trace organics through the food web resulting in potential harm to fish-eating birds and mammals (including humans). Identifying the location and extent of possible impacts remains a key challenge in the design of an effective monitoring program.

Contaminants associated with urban runoff include polycyclic aromatic hydrocarbons (PAHs), metals and petroleum hydrocarbons associated with vehicle exhaust, brake and tire wear, fuel and engine oil leaks or spills, and corrosion. Other contaminants associated with roads and urban runoff include suspended solids, nutrients, pesticides and bacteria from sanitary sewer cross connections, infiltration from the sanitary sewer system, accidental or deliberate spills to road side catch basins, chemical applications (fertilizers and pesticides) run off from commercial/industrial storage areas, and faecal material from wildlife and domestic animals.

Pollutants linked to rural and agricultural land uses can overlap to some degree with urban sources and include suspended solids, nutrients, pesticides, and bacteria. Sources would include fertilizer and pesticide applications, run off from animal storage areas, and faecal material from livestock. The relative impact of suspended solids, fertilizers and pesticides on rural streams can vary widely with the season and local farm practices but can be significant, particularly during the spring.

Not all pollutants are locally or recently generated. Many of the persistent "trace organic compounds" which can still be detected in the water, sediment, and biota of Lake Ontario and its tributaries are pesticides which have not been used in Ontario for decades (if ever) and which may be partially attributable to long-range atmospheric transport from other parts of the globe. Spatial and temporal trends in water quality throughout this area of the province can often be attributed to shifts in land use patterns, as well as reductions in contaminant loads from wastewater discharges over the past 20 years.

2.2.2 Selection of Water Quality Indicators

Effective water quality monitoring requires more than the collection and analysis of water samples. Many persistent contaminants of concern are hydrophobic (i.e. they have low solubility in water) and hence tend to bind to sediment particles or become incorporated into fatty tissue in animals. For this reason the life cycle of many of these contaminants includes a potentially protracted association with lake bottom sediments, as well as transmission through the food web. For this reason sediment sampling provides a means of tracking the legacy of historical contaminant loadings, and biological tissue analysis provides a means of assessing biological exposure to persistent, bioaccumulative substances. Assessment of other biological indicators such as the identification and enumeration of benthic invertebrate species also provides a means of linking chemical contamination of water and sediment with an impact on the biological community.

Surface water sampling is undertaken for a wide range of water quality, sediment quality, and biomonitoring parameters (samples are analysed for >150 chemicals, depending upon the specific objectives associated with program sub-projects). A subset of general indicators which illustrate the relationships between land use and pollution, and the subsequent potential impact on the aquatic environment, are presented here. Additional, detailed information is available in MOE publications and scientific papers which are produced as part of the monitoring program (see Appendix B).

Program Activity	Selected Indicators
Provincial Water Quality Monitoring Network (PWQMN), Intake Monitoring, and Lake Ontario Nearshore Index Station Monitoring	*Chloride, turbidity, total phosphorus and nitrate*
Lake Ontario Tributary Toxics Monitoring	*Total PCBs, total PAHs, Copper, and Zinc*
Lake Ontario Nearshore Index Station and Lake Ontario Nearshore Reconnaissance Monitoring for sediment quality	*Particle size, PCBs, PAHs , Copper Lead, and Zinc*
Lake Ontario Toxics Biomonitoring (Juvenile fish)	*Total PCBs and total DDT*

2.2.3 Chloride

Chloride is a naturally occurring ion associated with dissolved salts; the most common of these being rock salt (sodium chloride) and is an example of a conservative water quality pollutant. Rock salt is the most commonly used deicing salt used in southern Ontario and is the largest single source of chlorides entering Lake Ontario from local sources. Although typical concentrations found in the basin are well below any guidelines for protection of domestic water supplies, industrial water supplies, irrigation, or fish and aquatic life, in some cases (particularly during the spring snowmelt) shock loads of chloride can cause peak concentrations high enough to cause harm to aquatic life. Regardless of its potential as a harmful substance, chloride is also a good tracer for other pollutants associated with runoff from roads and urban areas.

2.2.4 Turbidity

Turbidity is a measure of water clarity and is largely an indicator of total suspended solids although discolouration associated with dissolved solids is also a factor. As with chloride, typical concentrations of suspended solids throughout much of the year do not necessarily cause any direct stress to aquatic life or impose undue restrictions on beneficial water uses such as recreation. However (unlike chloride) concentrations throughout the year tend to vary widely due to the link between flow and suspended solids concentrations in tributaries and at tributary mouths. These potentially extreme fluctuations can exert considerable stress on aquatic life, particularly in tributaries where the potential to avoid the affected area is limited, and particularly during critical periods such as spawning migrations. Apart from its potential to cause direct harm, turbidity is a good complementary indicator to chloride in that it is a good tracer of hydrophobic contaminants such as metals and trace organics. In many cases these types of contaminants are found at extremely low concentrations in water except in areas with high turbidity.

2.2.5 Nutrients (Phosphorus and Nitrate)

Phosphorus is an essential nutrient for plant and animal growth. Total phosphorus is a measure of all dissolved and particulate forms of phosphorus and in southern Ontario is generally the nutrient responsible for "cultural" eutrophication (i.e. the unnatural enhancement of algal productivity and the resulting enrichment of organic matter and depletion of oxygen) which can threaten aquatic habitat and impair the aesthetic value of lakes and streams.

Phosphorus enrichment is often linked to agricultural runoff from poorly protected soil containing fertilizer, or directly from faeces in situations where access to tributaries is provided for livestock watering. It can also result from faulty septic system operations in rural areas. Enrichment can also occur in urbanized watersheds as the result of sewage treatment plant (STP) discharges, combined sewer overflows following heavy rain (containing untreated sanitary sewage), and storm sewers channelling runoff containing animal faeces and fertilizer from lawns. Although excess phosphorus loading to Lake Ontario is not a new issue and has successfully responded to improved treatment at point sources such as STPs, contributions from the diffuse sources mentioned above means that it is still extremely common to find concentrations in tributaries and at tributary mouths which exceed the interim Provincial Water Quality Objective (PWQO) for avoidance of nuisance concentrations of algae. The link between agricultural and residential application of fertilizers and pest and/or weed control chemicals means that total phosphorus can also be a tracer of "in use" pesticides and herbicides.

Nitrate is a naturally occurring form of nitrogen found in soil and is another essential nutrient for plant growth (although it is seldom the limiting nutrient linked to eutrophication in the Great Lakes Basin). It is also highly soluble and can leach into tributaries and groundwater. Although there are health effects associated with high nitrate levels in water, typical concentrations found in the Lake Ontario basin are well below Ontario Drinking Water Objectives (PDWOs), and are far below any concentrations documented to have resulted in impairment of livestock water supplies. The detection of increased concentrations in the vicinity of STP discharges is usually evidence of ammonia nitrification which consumes oxygen and can result in harmful oxygen depletion if it occurs in the receiving water body rather than the treatment plant.

Nitrate enrichment patterns associated with urban and rural land use practices are generally similar to phosphorus (i.e. nitrate precursors are also a significant component of fertilizer and animal waste). This pattern is complicated by naturally occurring nitrogen fixation from the atmosphere (chiefly by soil bacteria and legumes) and the complex nitrogen cycle. Consequently, its use as a tracer of human activity and pollution is less direct than phosphorus. It is worth noting that its limited role in cultural eutrophication (and hence oxygen depletion and production of nuisance algae) has meant that it has not been targeted for loading reductions throughout the Great Lakes basin.

2.2.6 Trace Organics (total PCBs, total DDT, and total PAHs)

Polychlorinated biphenyls (PCBs) are now ubiquitous in the environment and can be detected globally in sparsely populated, non industrialized environments such as the Canadian arctic. This widespread pattern of detection stems from historical uses in electrical equipment (transformers, capacitors), heat exchangers, plasticizers, hydraulic fluids, inks, adhesives, and flame retardants prior to 1971. Although the manufacture of PCBs stopped in the late 1970s,

there are still large quantities in use in closed electrical systems as well as accumulations in historical landfill sites. Local influences are observable in water, sediment, and tissue concentrations in addition to the general effect of global recycling through long range atmospheric transport and deposition. The limited water quality data available indicate that concentrations of total PCBs greater than the PWQO of 1.0 ng/L are still relatively common in tributaries, although sediment and tissue data suggest that they are significantly less than historical concentrations.

Use of the insecticide DDT in North America started in the 1940s, peaked in the 1960s, and was phased out in the 1970s following the discovery of its persistence and tendency to biomagnify through the food web causing harm to top predators (most notably through the reproductive failure of birds of prey). In some parts of the world it is still used on a large scale as a means of controlling malaria. DDT is metabolized in living organisms into DDD and DDE and since the sale and use of DDT has been eliminated in Ontario it is unusual to detect DDT itself in water, sediment, or biota. The most commonly detected form is now DDE which is the most persistent and most toxic metabolite. Similar data limitations exist for DDT as for PCBs, but it is apparent that total DDT is less frequently detected in tributaries at concentrations exceeding its PWQO (of 3.0 ng/L) than PCBs. Sediment and tissue data also suggest that current levels of DDT in Ontario have responded in a satisfactory manner to the policy of use restrictions and phasing out.

Polycyclic aromatic hydrocarbons (PAHs) represent a category of persistent organic pollutants which arise as byproducts of manufacturing and combustion, hence their typical association with vehicle exhaust and steelmaking operations which employ coking ovens. They are also produced through combustion of wood (including forest fires) and consequently differ from PCBs and DDT in that they are not synthetic chemicals produced strictly through human activity. The existence of low level background concentrations of PAHs in the environment, however, does not obscure their use as a tracer of urban and industrial activity, given that they are a major constituent of crude oil and creosote (which is derived from coal tar). They also differ from chlorinated substances such as PCBs and DDT in that most living organisms can metabolize them and hence they do not biomagnify through the food web. They are, however, persistent and (in some cases) can bioaccumulate causing harm during the metabolization process. Certain PAHs have been linked to cancer and genetic damage.

PCBs, DDT, and PAHs are examples of those contaminants of concern which are relatively insoluble in water and tend to be adsorbed to suspended sediment and organic matter in the water column. As a result, analysis of water samples for trace organic contaminants has been hampered by their extremely low concentration in ambient water relative to analytical detection limits (except in extremely turbid water). When the particulate material settles out, these contaminants are transported into the bed sediment where they can enter the benthic food web, or be re-introduced into the water column by physical resuspension or chemical desorption. The tendency for these contaminants to preferentially bind to sediment means that in many cases it is more effective to monitor sediment and biological tissue chemistry rather than water, in order to observe the effects of contaminant sources or as a means of tracking the effectiveness of remedial actions.

2.2.7 Metals (Copper, Lead, Zinc)
Unlike many of the trace contaminants previously discussed, metals are naturally occurring elements found in the earth's crust. They are also good tracers of a wide range of industrial activity, as well as urbanization. Copper, lead, and zinc have been selected as indicators of "metal pollution" since they are still commonly in use and frequently detected in the waters and sediment of southern Ontario.

Certain forms of copper are relatively soluble compared with other metals, and consequently copper tends to be the most commonly detected metal in the surface waters of southern Ontario. It's use in piping is well known and is one direct source of enrichment in urban settings since most household waste water will have travelled through copper pipe as part of the supply system. It is also widely used in metal alloys, wiring, and in insecticides and fungicides and consequently can be a tracer of a wide range of urban and rural land use practices. It is not found in Ontario at sufficiently elevated concentrations to represent a human health concern.

The use of lead as a fuel additive (until it was phased out during the 1980s), in paint, as solder, and as shot is well known and accounts for the ubiquitous nature of lead enrichment in urban soil and sediment, and water. Lead has been linked to animal human health effects as a cumulative general poison with pregnant women, fetuses, and infants being at the greatest risk.

Although zinc is an essential element for plant and animal nutrition, its use in metal galvanizing and plating, as well as in dyes and paints means that enriched concentrations may be observed in urban and industrial watersheds, along with enrichment of sediment in Lake Ontario harbours. Like copper, it is not found in Ontario at sufficiently elevated concentrations to represent a human health concern.

Many metals are also relatively insoluble in water and, like trace organic substances, tend to be associated with suspended sediment and organic matter in the water column. This tendency also means that in many cases it is more effective to monitor sediment and biological tissue chemistry rather than water, in order to observe the effects of contaminant sources or as a means of tracking the effectiveness of remedial actions.

2.3 Selected Results from the Provincial Water Quality Monitoring Network (PWQMN)

Water quality data collected at PWQMN sites between 1996 and 1998 have been analyzed and median concentrations calculated for the selected water quality indicators at all of the monitoring sites across the Lake Ontario drainage basin. In order to simplify the presentation of results, an aggregate median concentration for each indicator was then determined at the fourth watershed level by pooling all station medians within a given watershed. In order to classify and compare these aggregate median concentrations, water quality results collected at all PWQMN sites across Ontario from 1994 to 1998 were pooled and analyzed to establish a concentration range for each water quality indicator. Four classifications within each concentration range were identified: "low" (0% to 25% of the observed concentration range), "low to medium" (25% to 50% of the observed concentration range) , "medium to high" (50% to 75% of the observed concentration range), and "high"(75% to 100% of the observed concentration range). These classification criteria were used to assign a corresponding colour to the watershed map. It should be noted that this scheme only provides a means of comparing typical concentrations of a water quality indicator in a given watershed to other levels of that indicator observed throughout other watersheds in Ontario. It does not purport to indicate a level of environmental risk or biological harm.

The long periods of record available at many PWQMN sites make these data well suited for examining long term trends in water quality. In this report, a 16 year trend interval has been examined by comparing a block of PWQMN data collected at sites from 1980 to 1982 with the block of data collected during the period from 1996 to 1998 at corresponding sites. A statistical examination of the variation in concentration about the median for each of the trend interval data blocks was used to provide a quantitative means of determining whether recent concentrations of selected parameters have increased, decreased or remained unchanged.

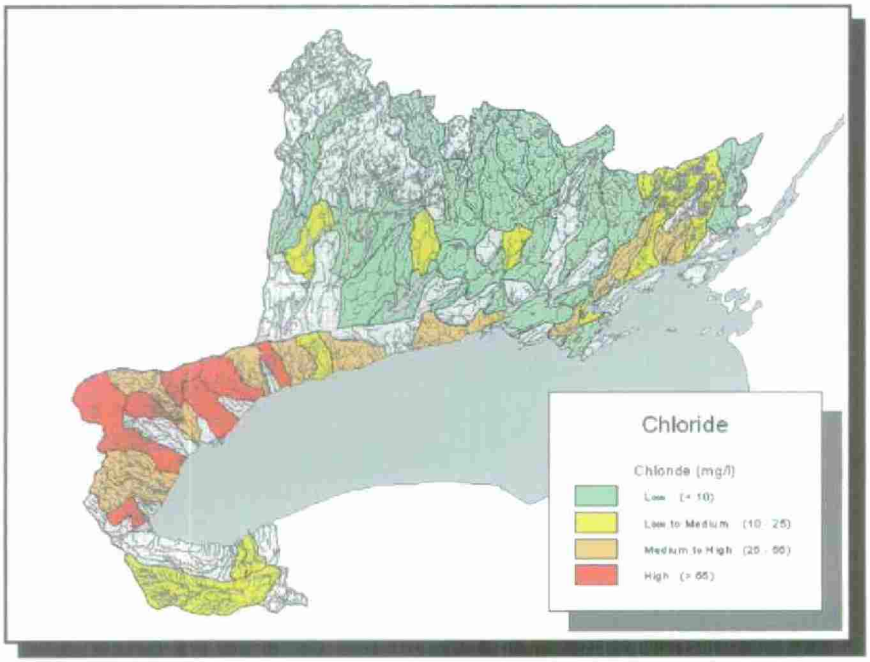

Figure 2.3.1: Median Chloride Concentrations for Lake Ontario Watershed Stations

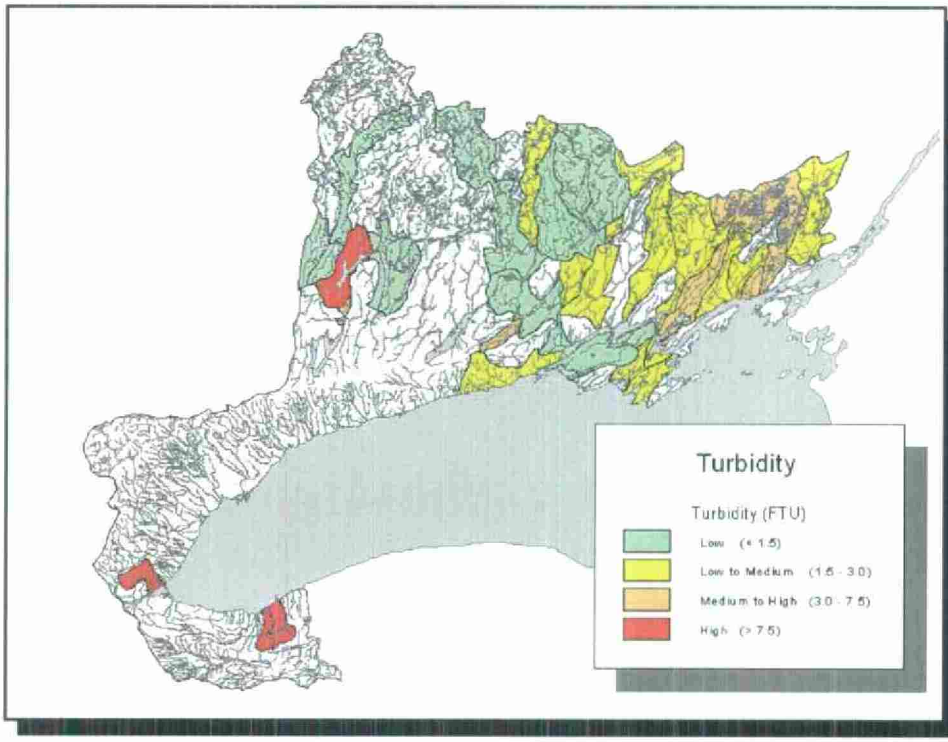

Figure 2.3.2: Median Turbidity Concentrations for Lake Ontario Watershed Stations

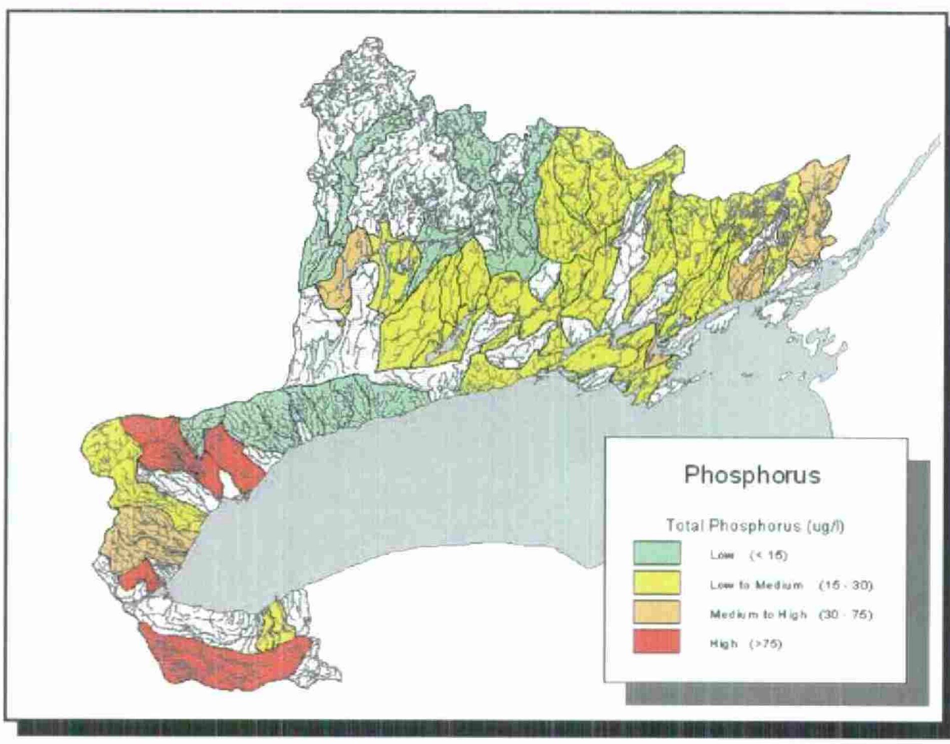

Figure 2.3.3: Median Phosphorus Concentrations for Lake Ontario Watershed Stations

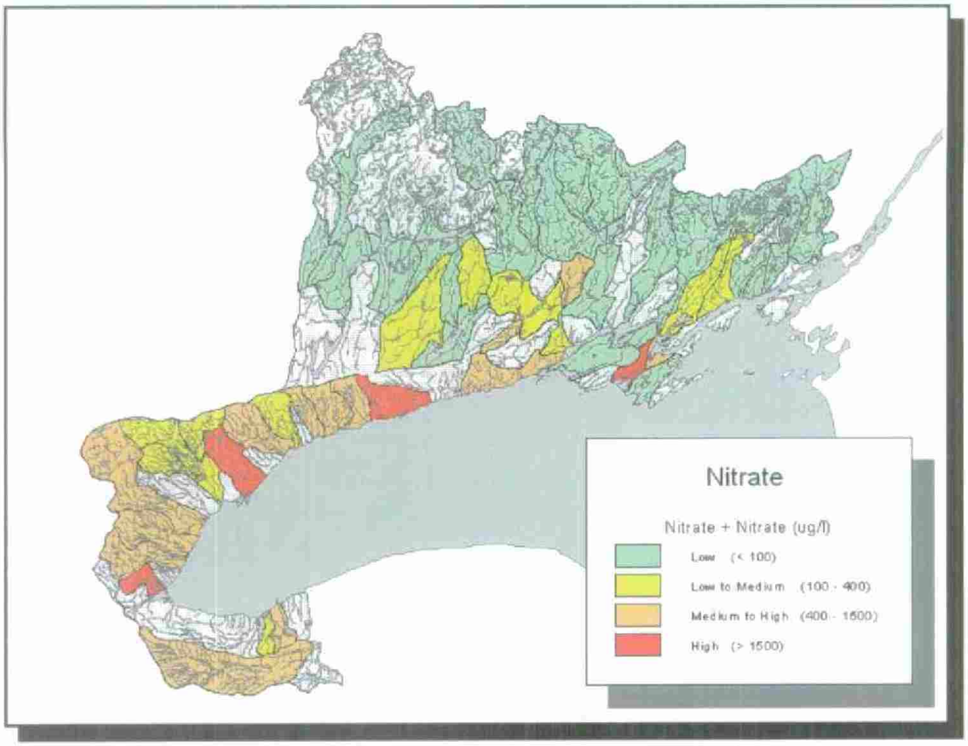

Figure 2.3.4: Median Nitrate Concentrations for Lake Ontario Watershed Stations

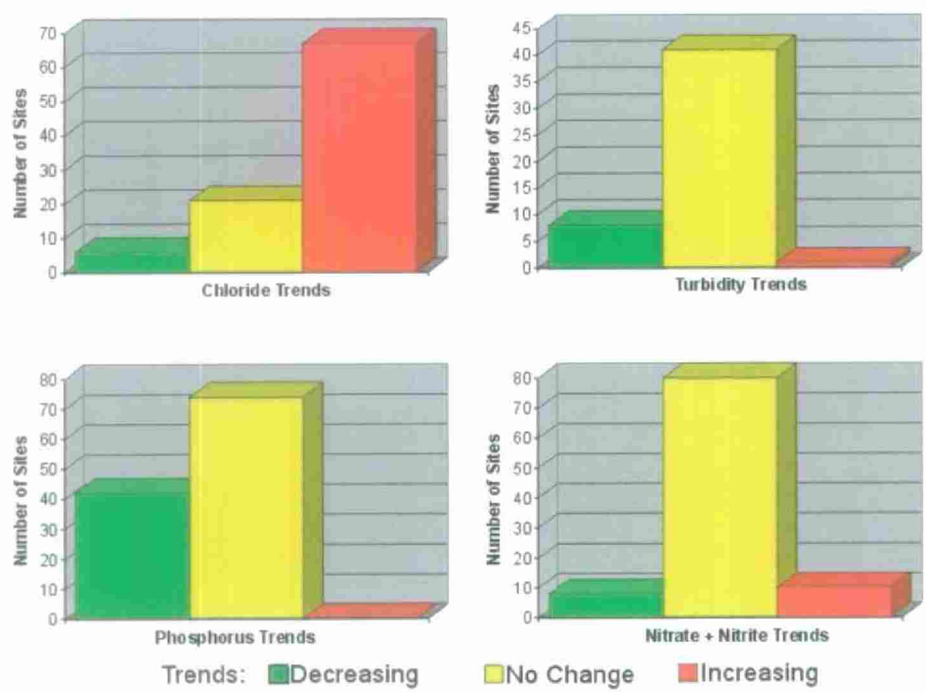

Figure 2.3.5: Summary of Chloride, Turbidity, Phosphorus, and Nitrate Trends in Lake Ontario between 1980-82 and 1996-98

As illustrated in the preceding figures, the pattern of chloride, turbidity, phosphorus and nitrate concentrations and trends strongly reflects the geographical pattern of urbanization and population growth.

"Medium" to "high" concentrations of chlorides are observable in the watersheds draining directly to the north shore of Lake Ontario. The highest levels can be observed in the watersheds of the Greater Toronto area which are intensely urbanized and support major transportation links with significant winter use of road deicing salts. Low levels of chlorides are generally observable in the Trent River and Kawartha Lakes system. Over the long term, 71 percent of PWQMN sites monitored in the Lake Ontario basin show increasing trends for chlorides, 22 percent show no change and seven percent show decreasing trends. This high percentage of sites showing an increasing trend is a clear reflection of the significant amount of urbanization and development which has occurred in watersheds in southern Ontario since the early 1980s. Although currently observed levels of chlorides may not pose a serious threat to aquatic wildlife, increasing chloride trends may indicate a pattern of related, more serious, pollutants such as PAHs.

These results show phosphorus levels in central and eastern Lake Ontario tributaries and in the Trent River and Kawartha Lakes systems to be generally in the "low" and "low to medium" category although there are isolated watersheds in the "medium to high" category. More than half of the observed watersheds in the "low" and "low to medium"category also represent surface waters with phosphorus concentrations below the interim Provincial Water Quality Objective (PWQO) of 30 μg/L to avoid nuisance algae growth. Watersheds around the western end of Lake Ontario from Toronto to Niagara with intense urban and agricultural land use activity generally exhibit phosphorus levels in the "medium to high" and "high" categories. The long term trends observed at PWQMN sites in the Lake Ontario drainage basin reflect improved treatment at point source discharges such as sewage treatment plants. Thirty six percent of sites show a decreasing phosphorus trend, 74 percent show no change in trend, and there were no sites in the basin with an increasing phosphorus trend, despite the increase in population growth over the period of comparison. These figures suggest that point source phosphorus control efforts have been a move in the right direction. However, there are watersheds with phosphorus levels that were routinely above the Provincial Water Quality Objective suggesting the need for further vigilance and action in controlling phosphorus from non-point sources such as runoff from urban and agricultural areas.

These data show that nitrate levels are predominately on the "low" end of the scale in eastern Lake Ontario tributaries and in the Trent River and Kawartha Lakes systems. Nitrate levels in watersheds around Lake Ontario from the Trent River to Niagara, on the other hand, are predominately in the "medium to high" category, with a few watersheds in both the "high" category and the "low to medium" category. The tendency for watersheds in the western drainage area for Lake Ontario to have nitrate levels towards the higher end of the scale can once again be attributed to the amount of urban and agricultural activity in these watersheds relative to eastern Lake Ontario. Long term trends, however, indicate no significant change in nitrate levels at 82 percent of monitored tributary sites. Ten percent of sites exhibit an increasing trend while eight percent have a decreasing trend.

The majority of the monitoring for turbidity has been confined to the eastern Lake Ontario tributaries and the Trent River and Kawartha Lakes systems where turbidity levels are typically observed in the "low" and "low to medium" categories. There are a few watersheds exhibiting "medium to high" and "high" levels. Long term trends indicate that turbidity levels at 83 percent of monitored sites show no significant change over time, 16 percent of sites have a decreasing trend, and one percent have an increasing trend.

2.4 Lake Ontario Tributary Mouth and Nearshore Water Quality Monitoring

Median contaminant concentrations for tributary mouth, and the nearshore zone of Lake Ontario (including results from intake monitoring) are presented below to provide a general illustration of conditions. As previously noted, wet weather events and runoff play a significant role in determining water quality in tributaries and the extreme nearshore zone of the lake despite their variable frequency of occurrence. Since 50% of the samples fall below the median concentration (by definition) it is evident that this value will depend largely upon the proportion of "wet" and "dry" samples represented in the data. A more sophisticated analysis of tributary and nearshore data can be achieved by partitioning the results according to tributary flow, lake currents, and weather conditions. However, this falls outside the scope of this report.

2.4.1 Tributary Toxics Monitoring

Recent improvements in methods of sample collection and analysis have yielded a limited number of results (12 to 15 samples depending upon location) for trace organic contaminants and metals collected near the mouths of tributaries flowing into Lake Ontario during 1997 and 1998.

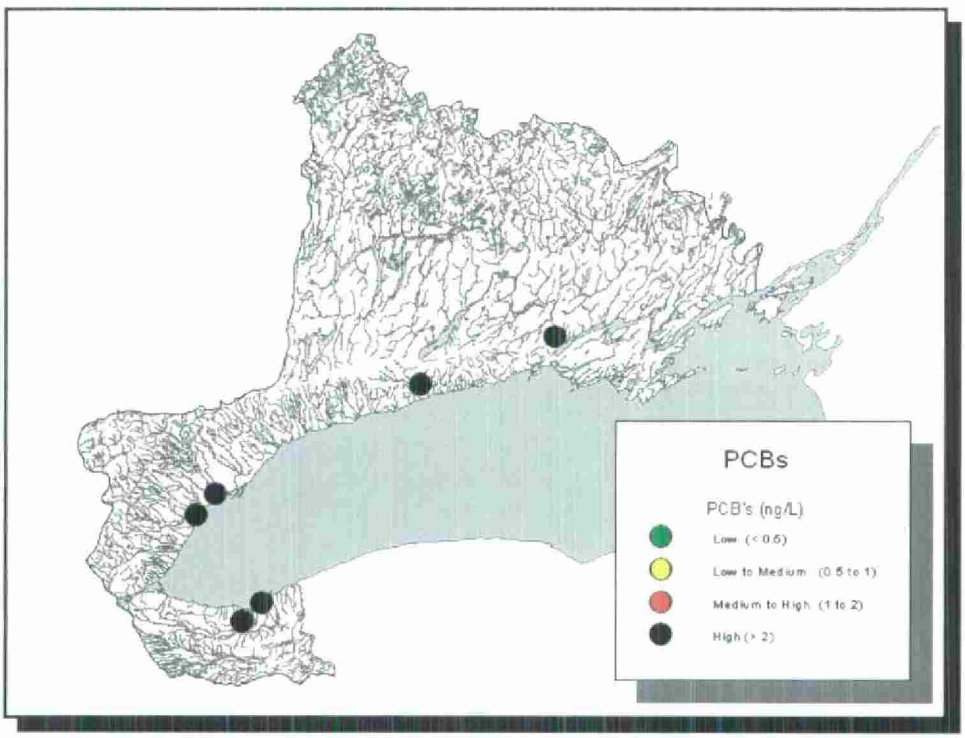

Figure 2.4.1: Median Concentration of PCBs from 1997/98 Tributary Toxics Sampling

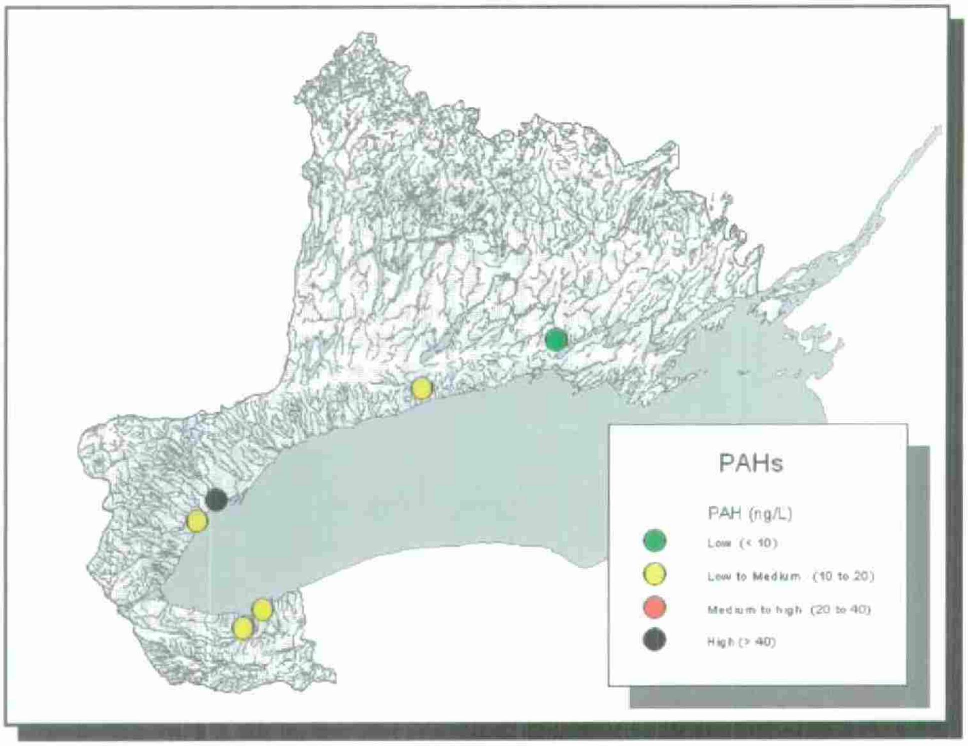

Figure 2.4.2: Median Concentration of PAHs from 1997/98 Tributary Toxics Sampling

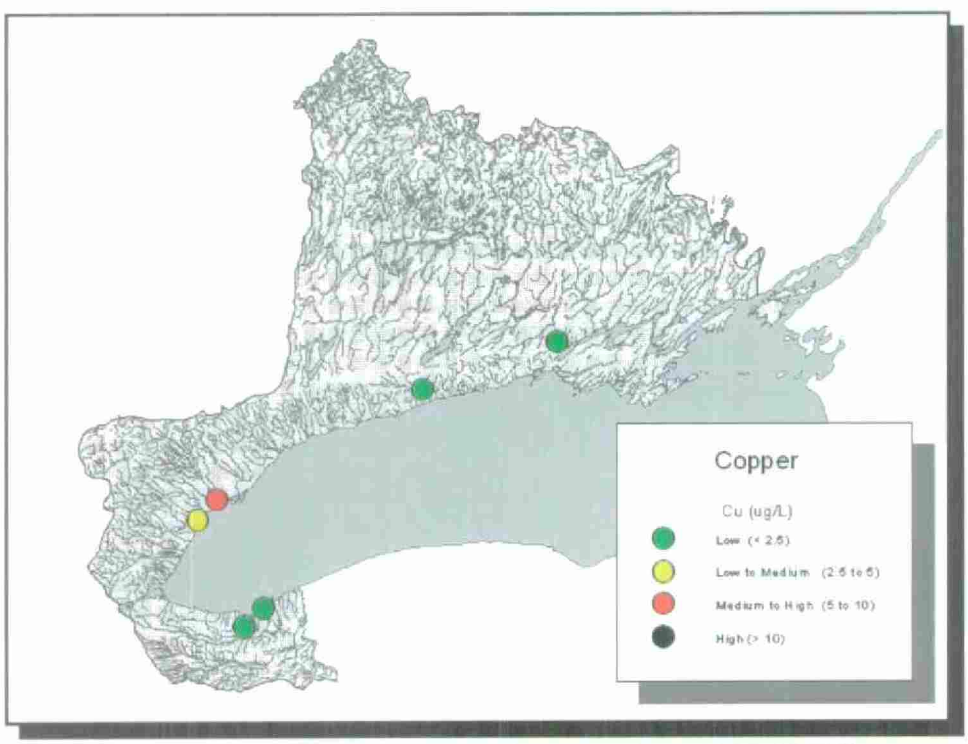

Figure 2.4.3: Median Concentration of Copper from 1997/98 Tributary Toxics Sampling

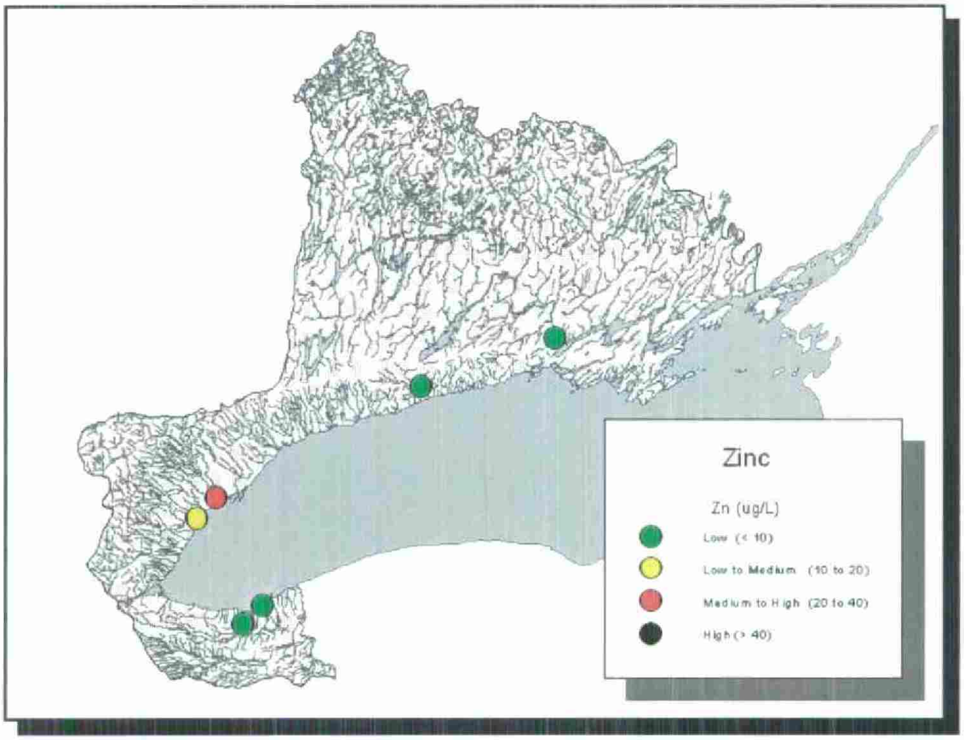

Figure 2.4.4: Median Concentration of Zinc from 1997/98 Tributary – Toxics Sampling

The ubiquitous and persistent nature of total PCBs is reflected in its routine detection above the current Provincial Water Quality Objective (PWQO) of 1 ng/L near tributary mouths around the Lake Ontario basin. Median concentrations are greater than twice this value at all locations. Although there is no PWQO for total PAHs (interim PWQOs for individual PAHs range from 0.02 ng/L to 7.0 μg/L) the tributary mouth data reflect land use, with median concentrations at Toronto area tributaries clearly exceeding those seen elsewhere around the lake. A similar pattern is evident for copper and zinc with median concentrations of both metals exceeding their respective PWQOs at the Humber River.

2.4.2 Lake Ontario Index Station Monitoring

Index stations in Lake Ontario are situated so as to avoid the immediate influence of local tributaries and consequently the chloride concentrations shown here are largely influenced by open lake ambient conditions (which are, in turn, influenced by flows from the Niagara River). This tendency accounts for the relatively uniform pattern observed at most sites in 1994 and 1997. The exceptions to this are the two largest urbanized areas, Toronto and Hamilton, which have had a measurable effect on a larger portion of the nearshore zone.

Secchi depth results (turbidity) are more variable both from site to site and year to year, although once again Hamilton and Toronto display a tendency for the lowest water clarity, along with Bay of Quinte, where eutrophication and increased algal productivity have historically been a problem. Total phosphorus concentrations appear fairly uniform around the lake and are generally below the open lake guideline of 20 µg/L, except at Hamilton Harbour and the Bay of Quinte (in 1994). Nutrient enrichment has been a significant problem at both areas as the result of large phosphorus loads entering restricted bodies of water with limited assimilative capacity.

Like phosphorus, increased nitrate concentrations are also evident at Hamilton Harbour (as the direct result of STP discharges). The Bay of Quinte, however, does not follow this pattern since increased nitrate loads have not been associated with the agricultural land use in eastern Ontario. The pattern of trophic status provided by the Millbrink index (which uses benthic invertebrates species composition and density data) reinforces the water quality interpretation. Generally oligotrophic (low nutrient) conditions now exist throughout the Lake Ontario nearshore zone outside of the Bay of Quinte and Toronto Harbour where mesotrophic (medium nutrient) conditions are now prevalent, and Hamilton Harbour where eutrophic (high nutrient) conditions remain.

The pattern of Lake Ontario zebra mussel colonization in 1994 and 1997 reflects the introduction from Lake Erie via the Niagara River, and the subsequent transport by boat traffic to the eastern end of the lake.

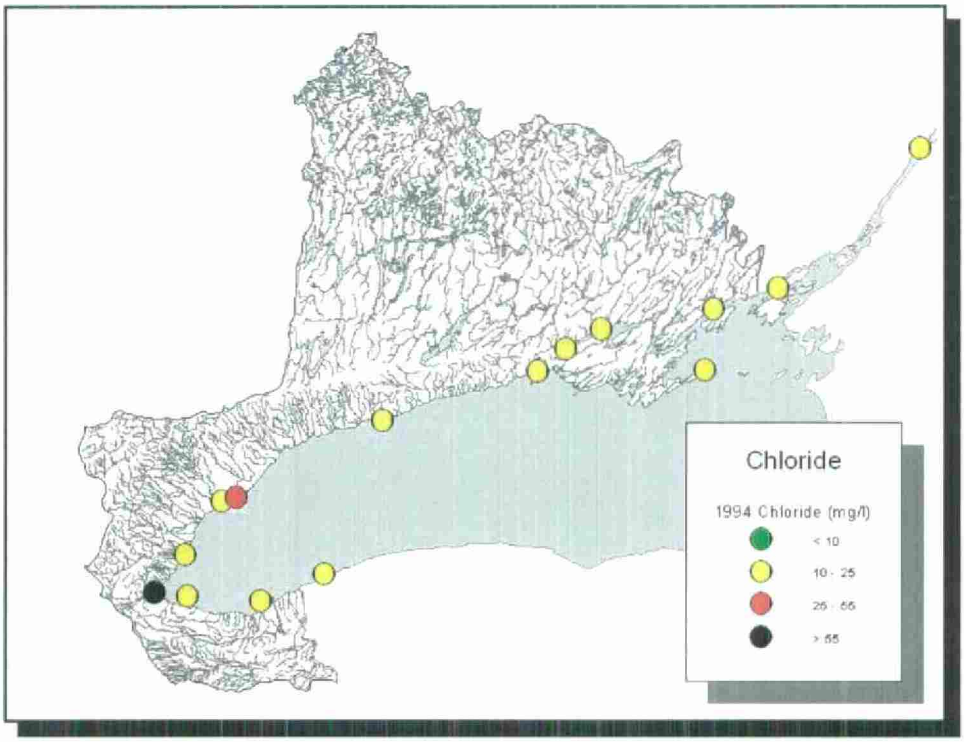

Figure 2.4.5: Median Concentration of Chloride at 1994 Lake Ontario Index Stations

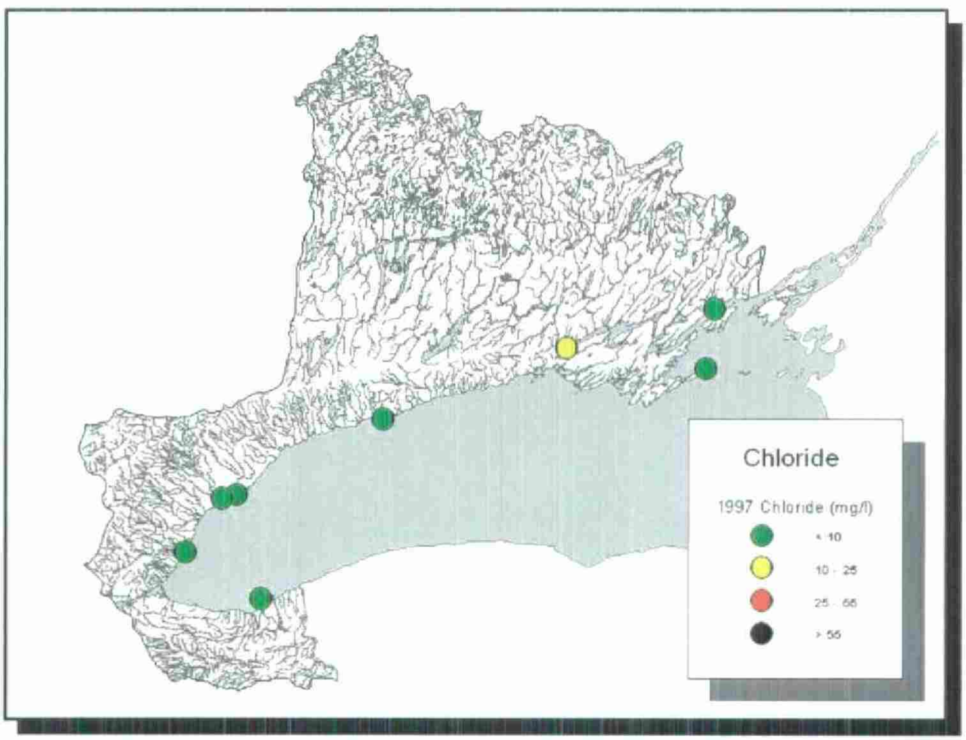

Figure 2.4.6: Median Concentration of Chloride at 1997 Lake Ontario Index Stations

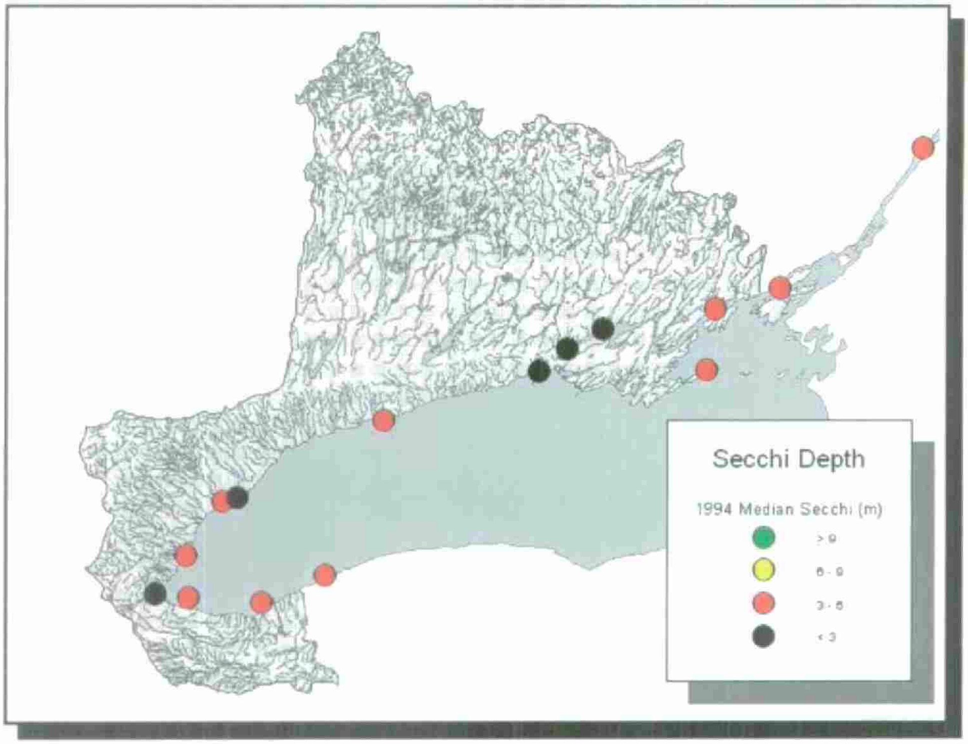

Figure 2.4.7: Median Secchi Depths (turbidity) at 1994 Lake Ontario Index Stations

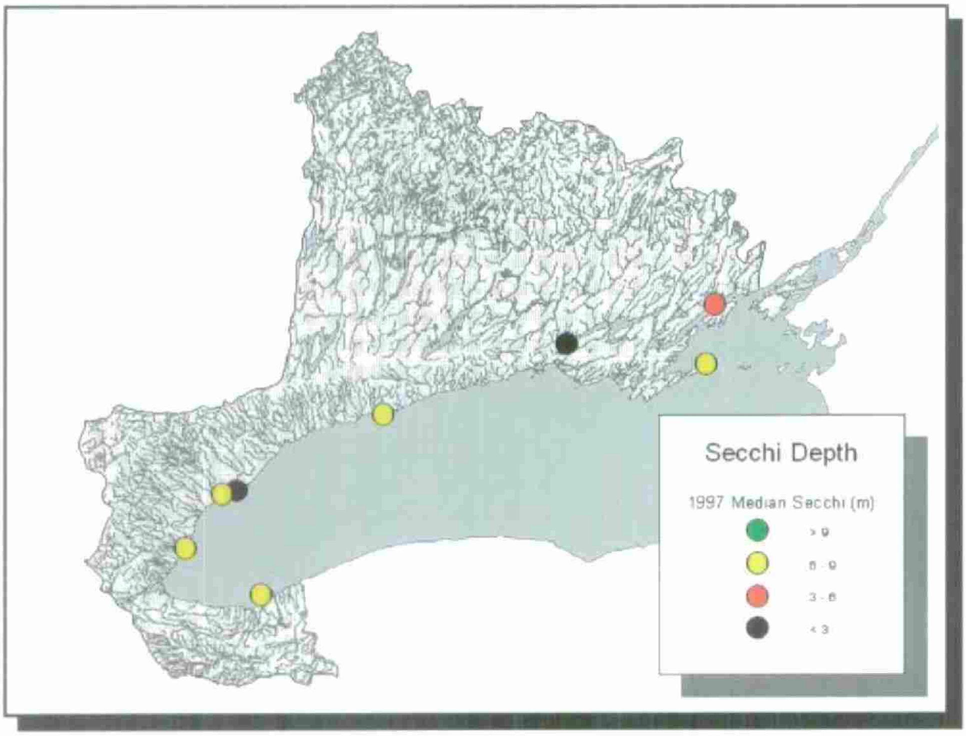

Figure 2.4.8: Median Secchi Depths (turbidity) at 1997 Lake Ontario Index Stations

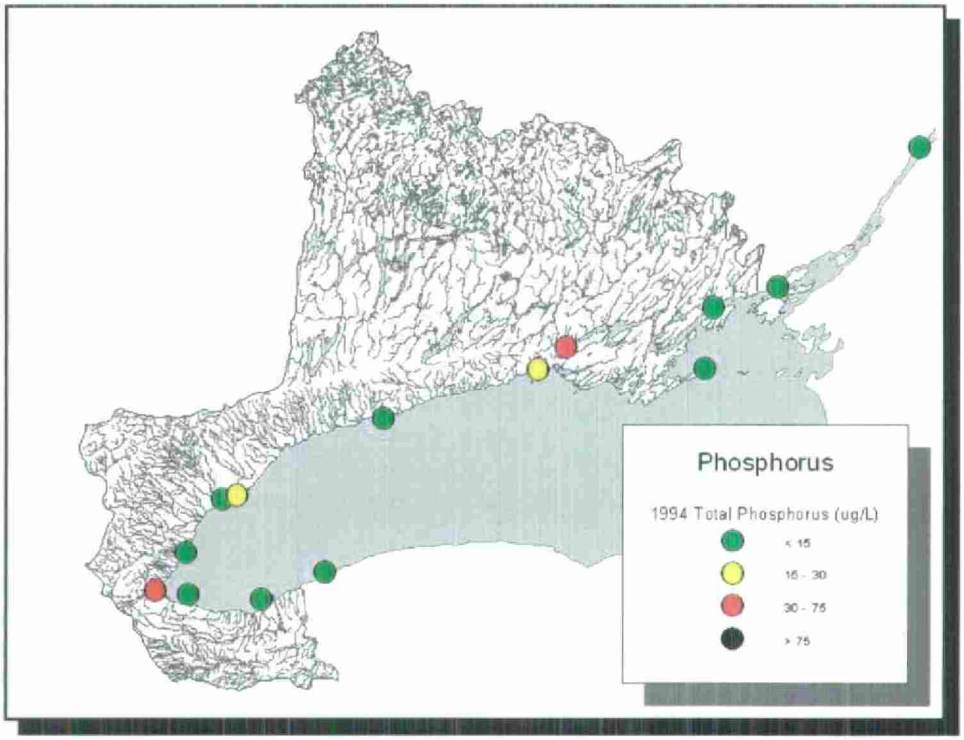

Figure 2.4.9: Median Concentration of Phosphorus at 1994 Lake Ontario Index Stations

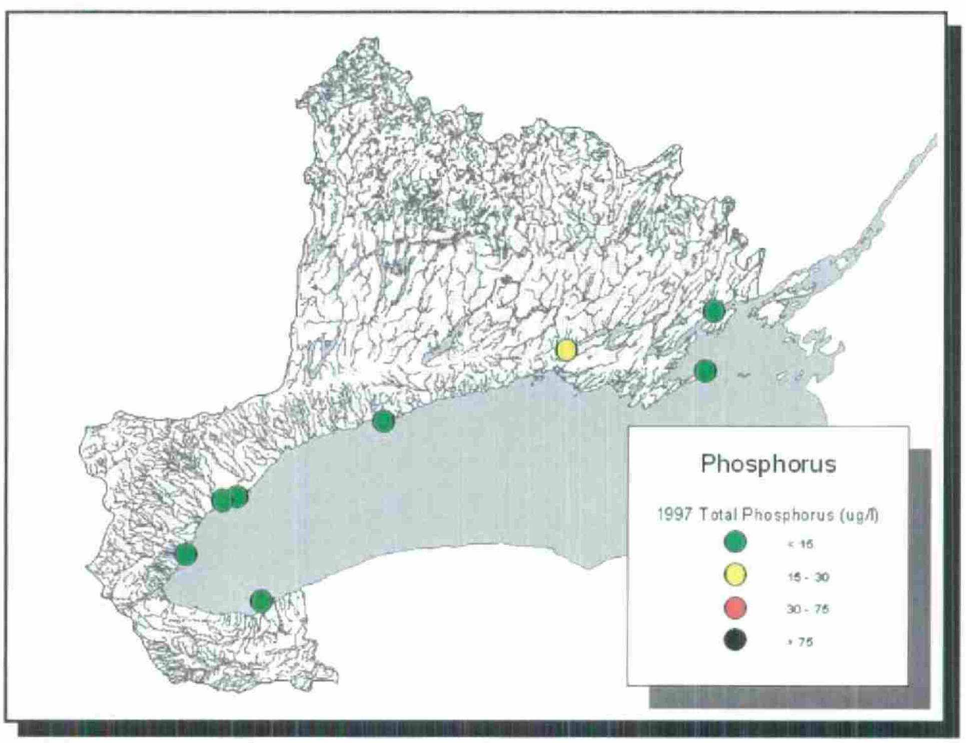

Figure 2.4.10: Median Concentration of Phosphorus at 1997 Lake Ontario Index Stations

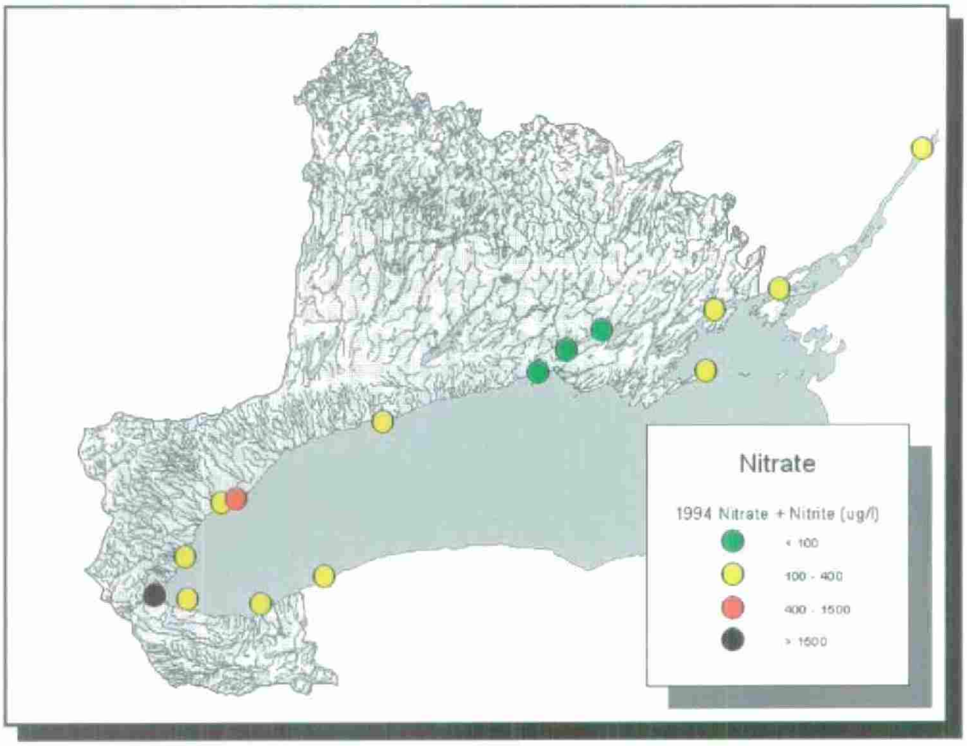

Figure 2.4.11: Median Concentration of Nitrate at 1994 Lake Ontario Index Stations

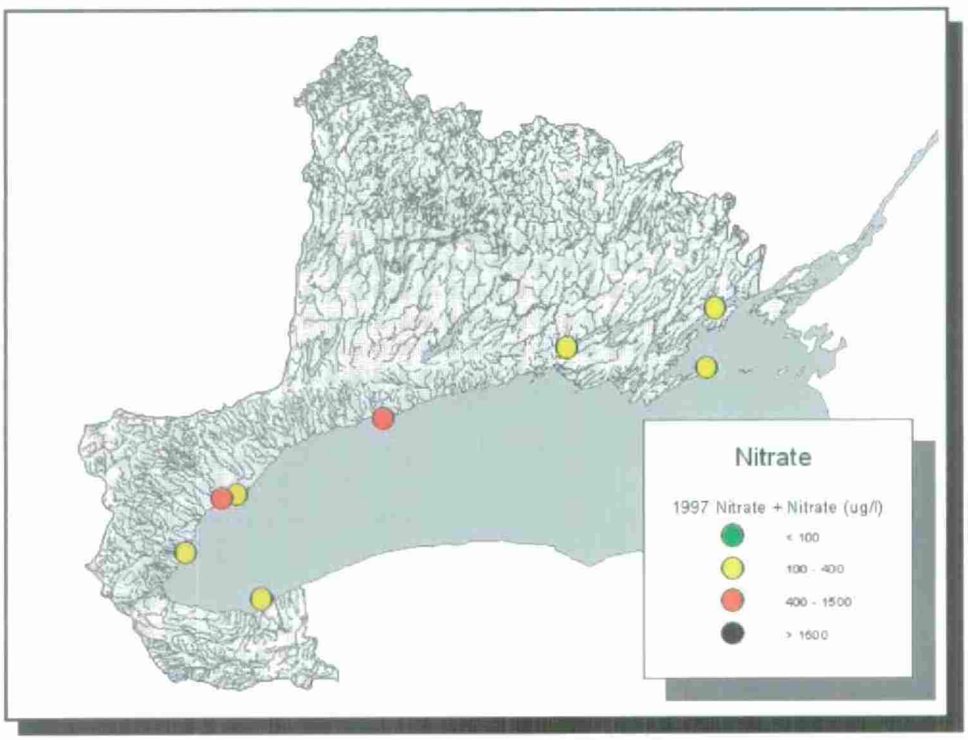

Figure 2.4.12: Median Concentration of Nitrate at 1997 Lake Ontario Index Stations

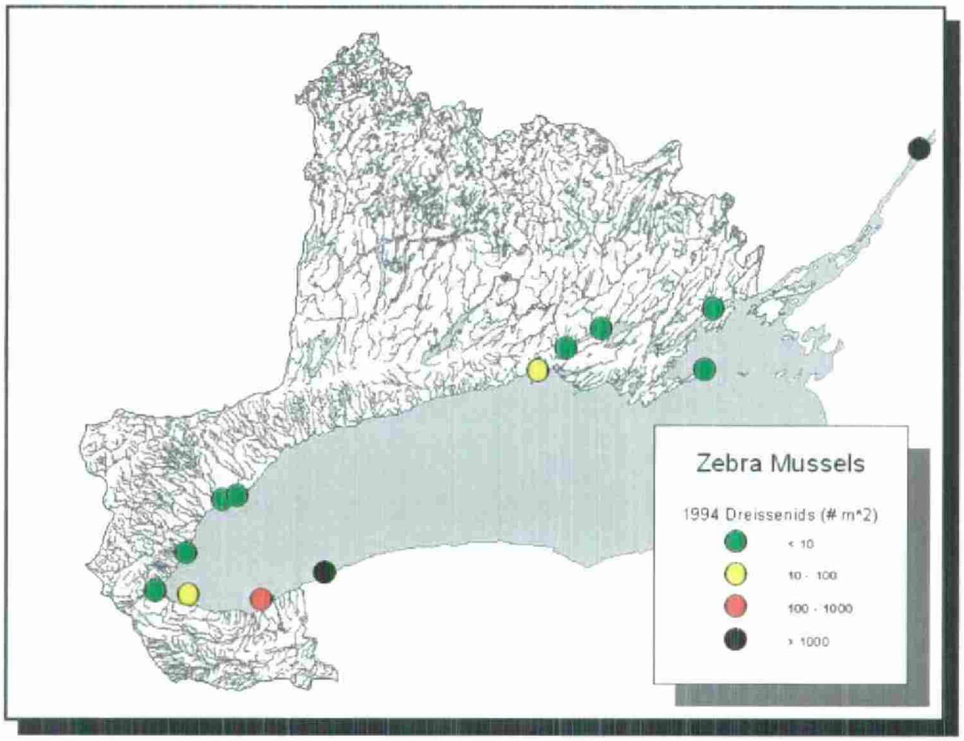

Figure 2.4.13: Median Zebra Mussel Densities at 1994 Lake Ontario Index Stations

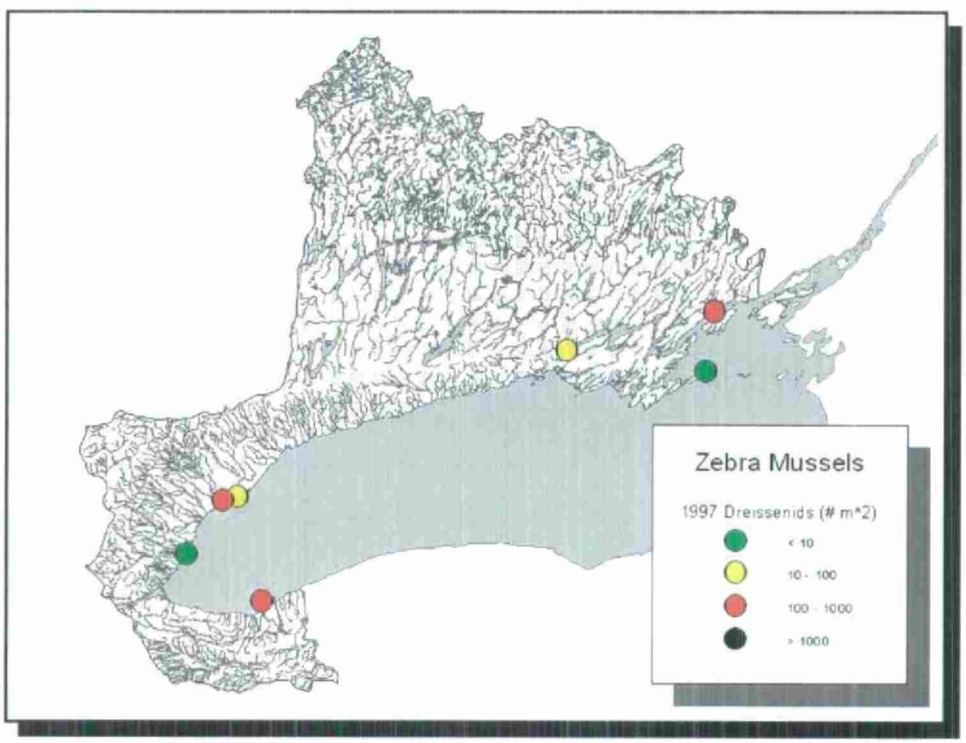

Figure 2.4.14: Median Zebra Mussel Densities at 1997 Lake Ontario Index Stations

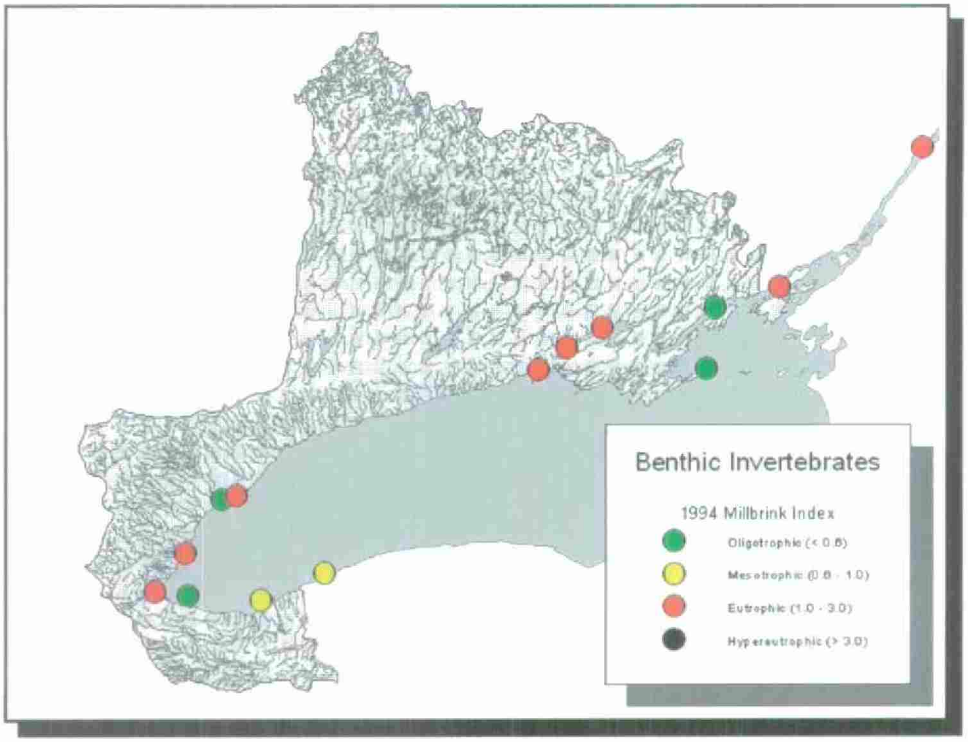

Figure 2.4.15: Benthic Invertebrate Index (Millbrink) for 1994 Lake Ontario Index Stations

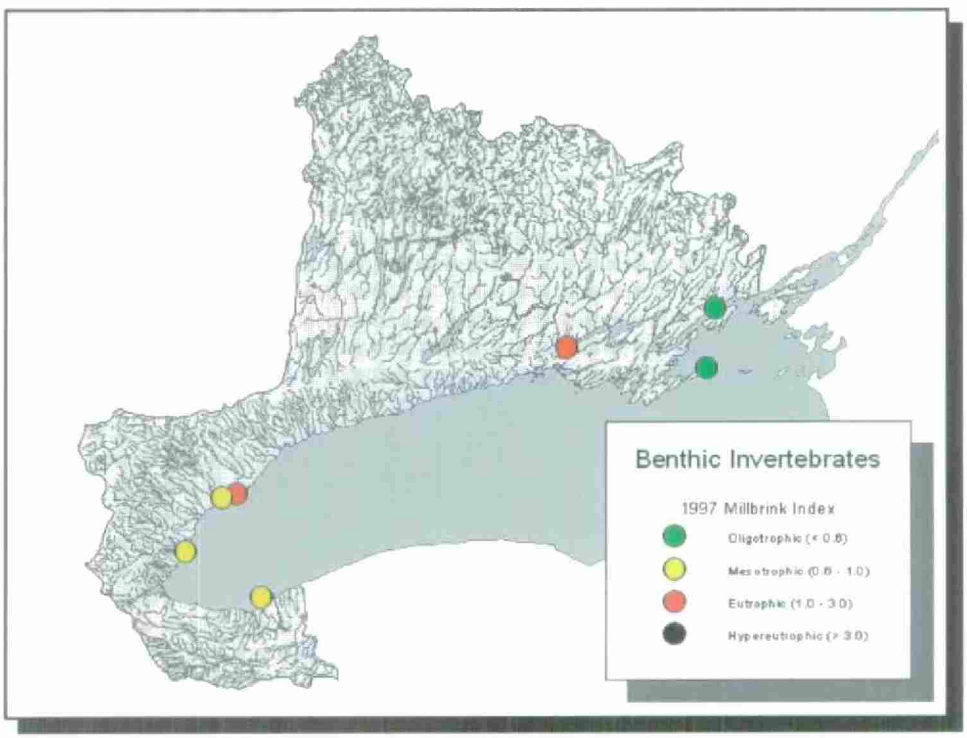

Figure 2.4.16: Benthic Invertebrate Index (Millbrink) for 1997 Lake Ontario Index Stations

2.4.3 Lake Ontario Water Intake Monitoring

The long term nature of the data available from water intake monitoring provides a good means of evaluating the long term water quality of nearshore waters in Lake Ontario. The same procedure used to evaluate trends in the PWQMN data was applied to water intake data yielding a comparison of the period 1980 to 1982 with the period 1996 to 1998.

Chloride trends between the early 1980s and late 1990s in the nearshore zone of Lake Ontario show a slight decrease, despite the increase documented in Lake Ontario tributaries. This apparent contradiction is actually another reflection of the tendency for ambient conditions in Lake Ontario to be influenced by flows from the Niagara River where long term trends have declined significantly from the 1970s as the result of changes in industrial practices in the St. Clair/Detroit River corridor.

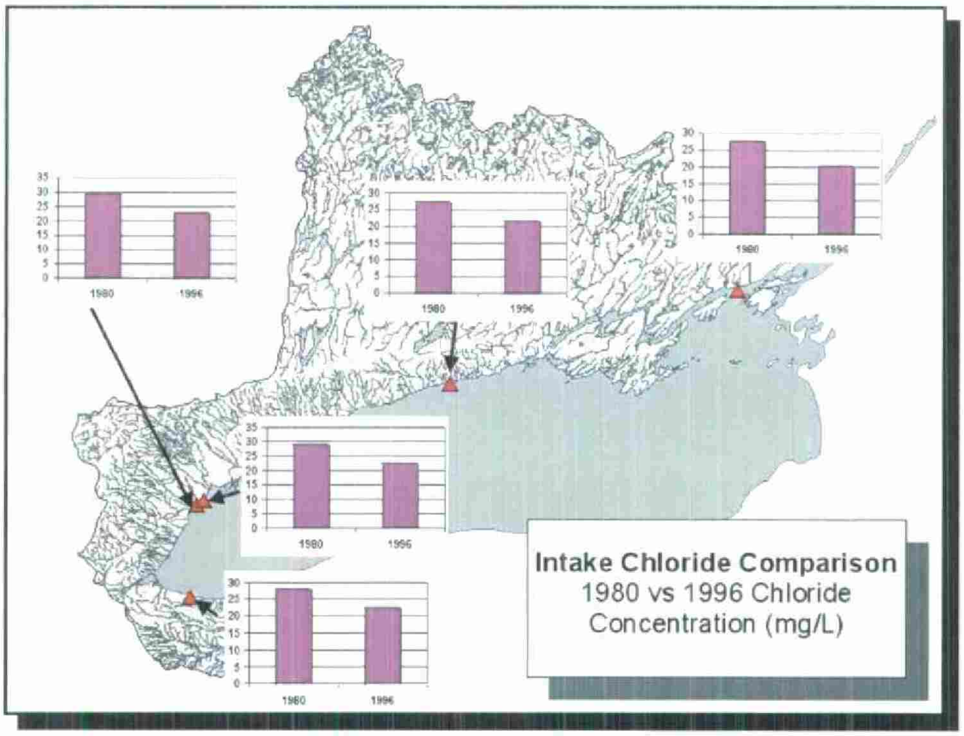

Figure 2.4.17: Chloride Trends at Lake Ontario Water Intakes

Phosphorus trends show an extremely large decrease over this period (despite increases in urbanization). The long term trend is chiefly attributable to the success of phosphorus loading reductions at municipal point sources throughout the Great Lakes basin. Recent reductions in phosphorus (and increase in water clarity) may also be linked to zebra (and quagga) mussel colonization as the result of their effectiveness at filtering organic matter and removing associated nutrients from the water column.

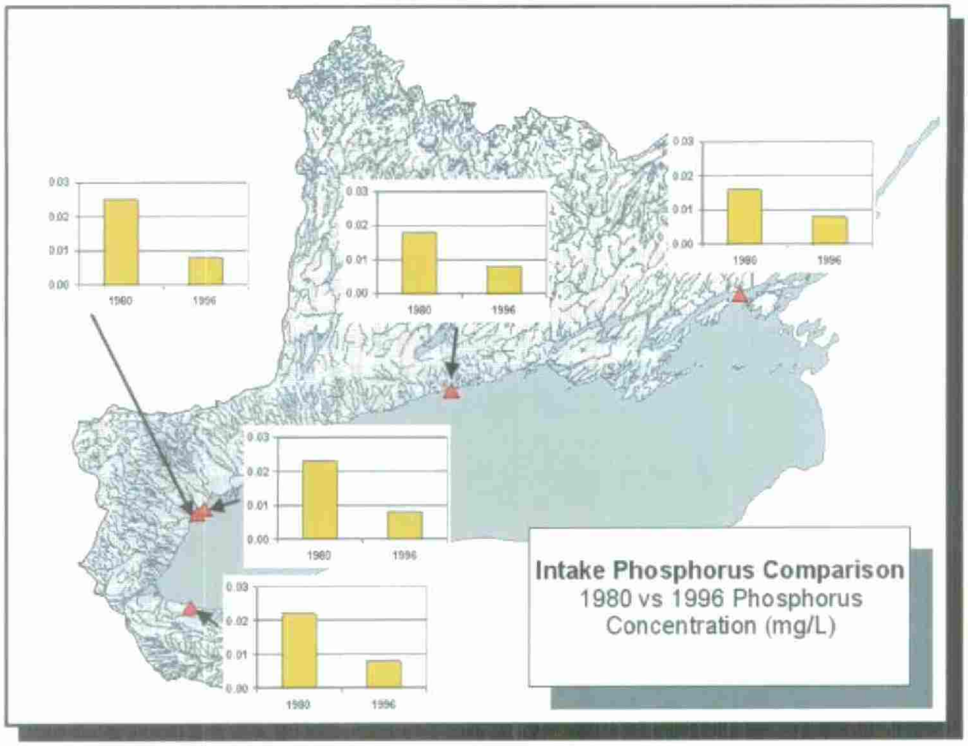

Figure 2.4.18: Phosphorus Trends at Lake Ontario Water Intakes

Unlike phosphorus, nitrate concentrations have not decreased at all; in fact, they have increased slightly. Nitrate has not been targeted for point source load reductions similar to phosphorus, so increased loads from STPs, as well as agricultural inputs, from southwestern Ontario via Lake Erie and the Niagara River are likely to be contributing to a gradual steady increase in ambient concentrations. These levels in Lake Ontario are not of concern relative to human water use criteria, however these trends may reflect a more serious groundwater contamination problem in southwestern Ontario.

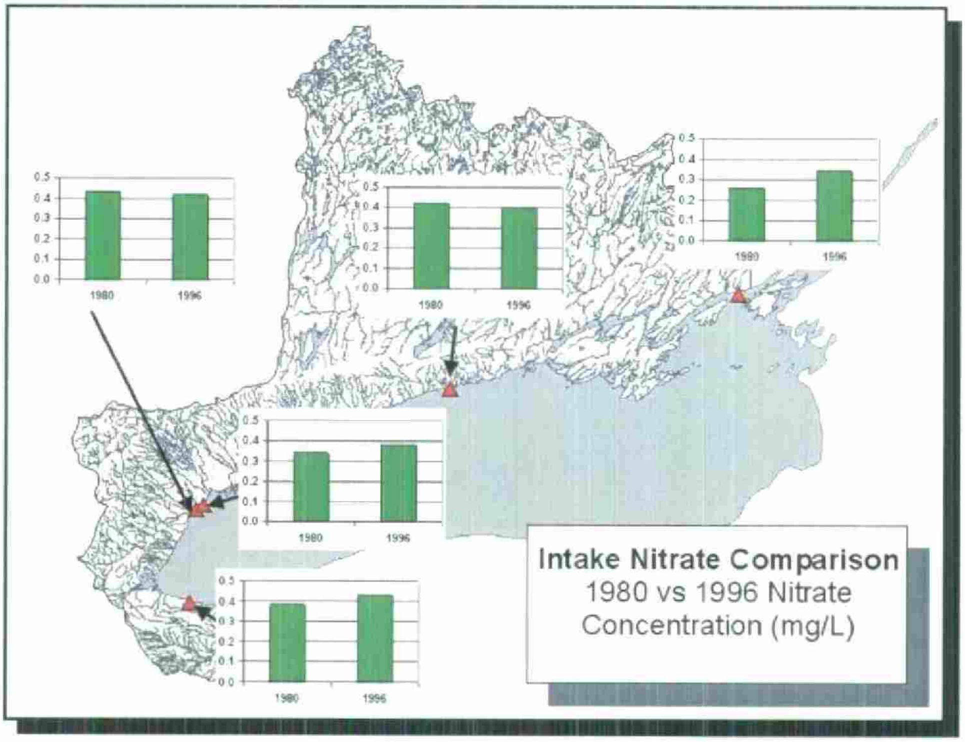

Figure 2.4.19: Nitrate Trends at Lake Ontario Water Intakes

2.4.4 Lake Ontario Reconnaissance Monitoring

The lake wide results from Index Station and Water Intake monitoring provide a good general picture of nearshore conditions. The situation is much more variable and extreme in the vicinity of tributaries and point sources such as industrial or municipal effluent discharges. Results of 1997 monitoring in the Toronto Waterfront are presented below as a means of illustrating this situation. As illustrated below, the presence of variable gradients in Lake Ontario water quality near sources makes it difficult to summarize conditions for an area such as the Toronto Waterfront as one number. The following results are median concentrations based on surveys undertaken during the spring, summer, and fall and even this degree of summarization masks some of the extremes in the data. Spring chloride, phosphorus, and nitrate peaks, for example, are more extreme than the seasonal medians show and are shown separately.

Local elevated chloride concentrations are observable in the vicinity of the Don River and throughout the Inner Harbour with more localized increases observable near Mimico Creek, the Humber STP outfall, the Humber River, and the Main STP outfall at Ashbridges Bay. A similar pattern can be seen for turbidity, phosphorus, and nitrate although the concentration gradients are steeper. The influence of the Main STP outfall on localized phosphorus and nitrate concentrations is particularly striking. The spring chlorophyll mapping illustrates the potentially large zone of impact which results from the lag time associated with algal growth in nutrient enriched water.

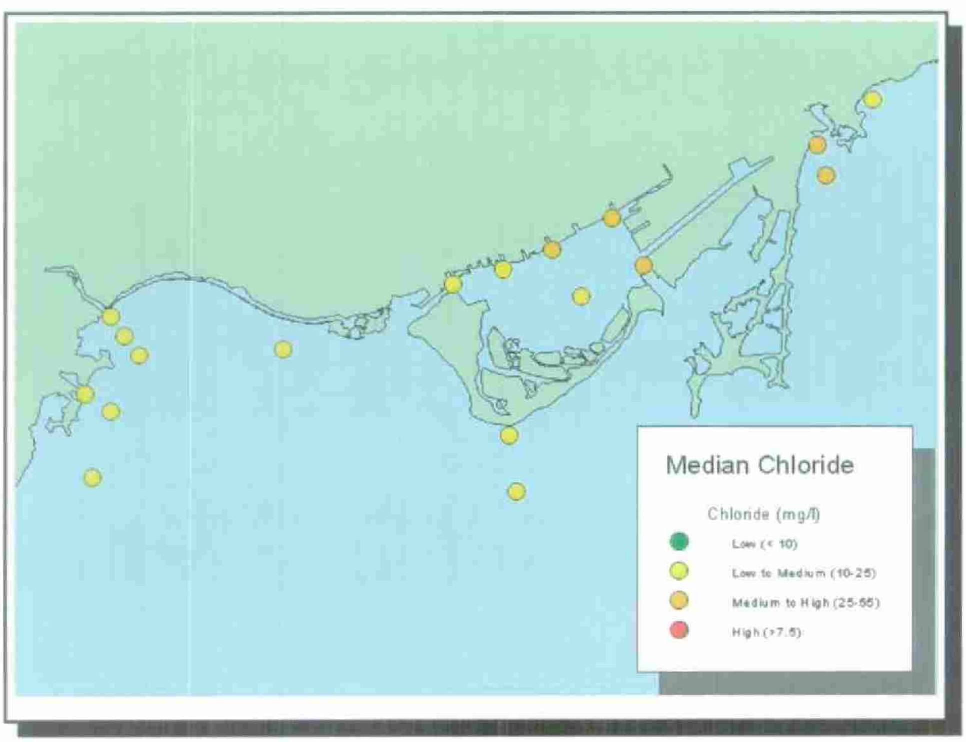

Figure 2.4.20a: Median Concentration of Chloride at 1997 Toronto Waterfront Stations

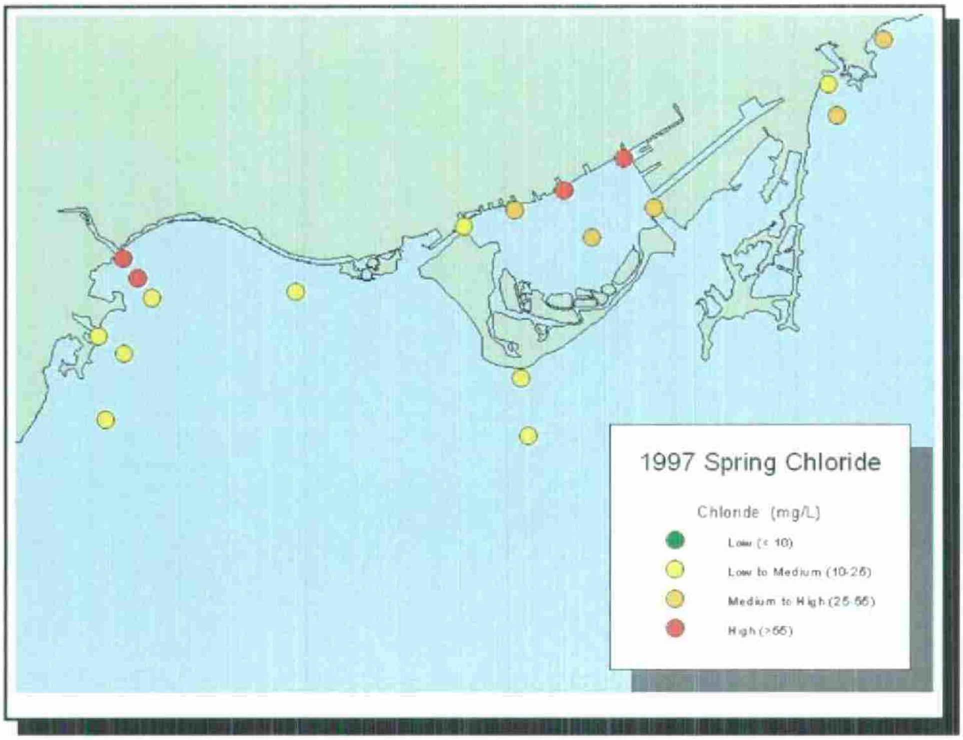

Figure 2.4.20b: Spring Concentration of Chloride at 1997 Toronto Waterfront Stations

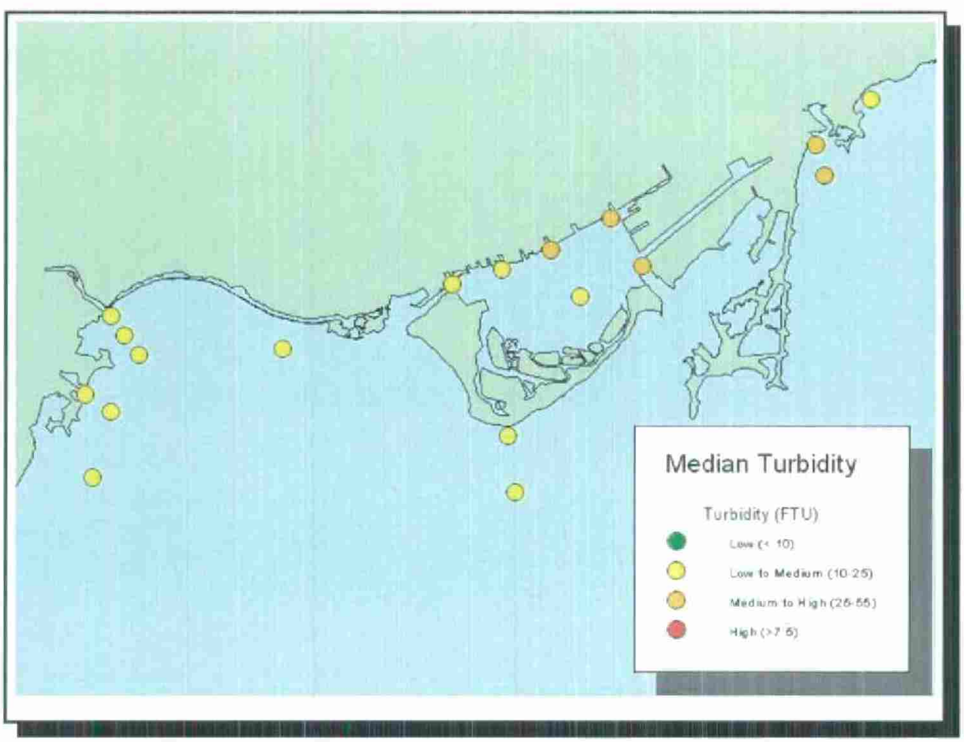

Figure 2.4.21: Median Concentration of Turbidity at 1997 Toronto Waterfront Stations

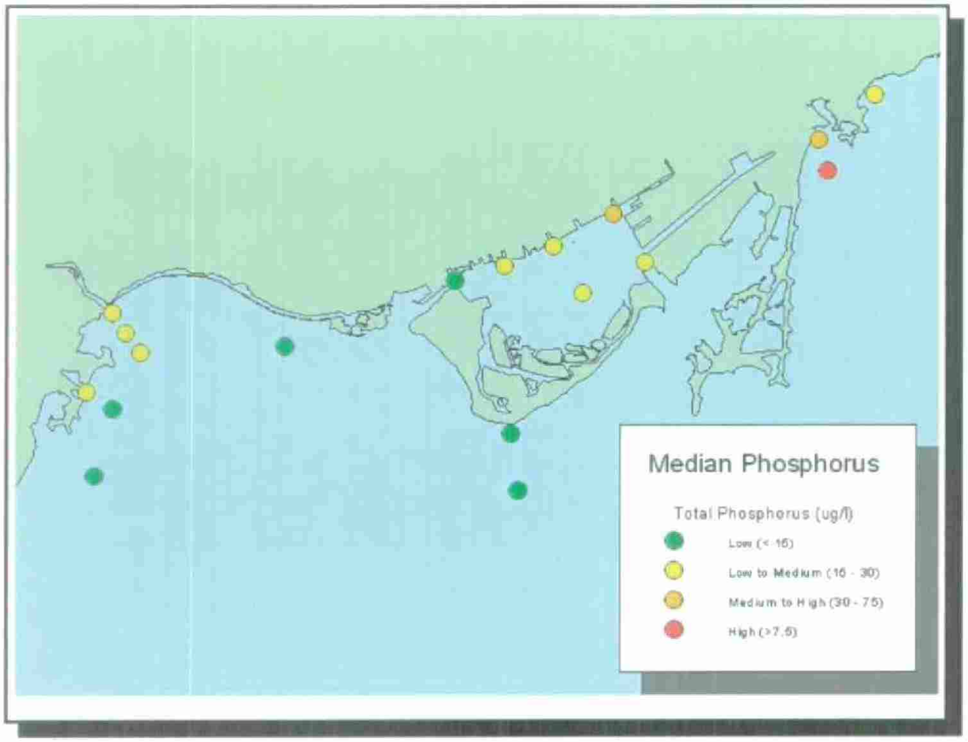

Figure 2.4.22a: Median Concentration of Phosphorus at 1997 Toronto Waterfront Stations

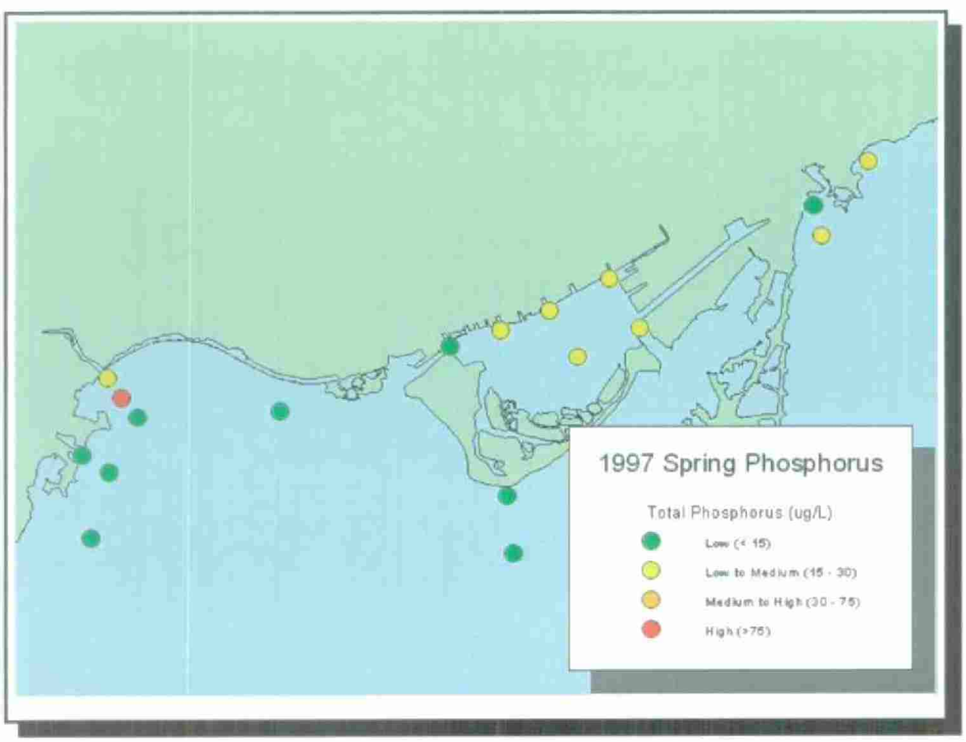

Figure 2.4.22b: Spring Concentration of Phosphorus at 1997 Toronto Waterfront Stations

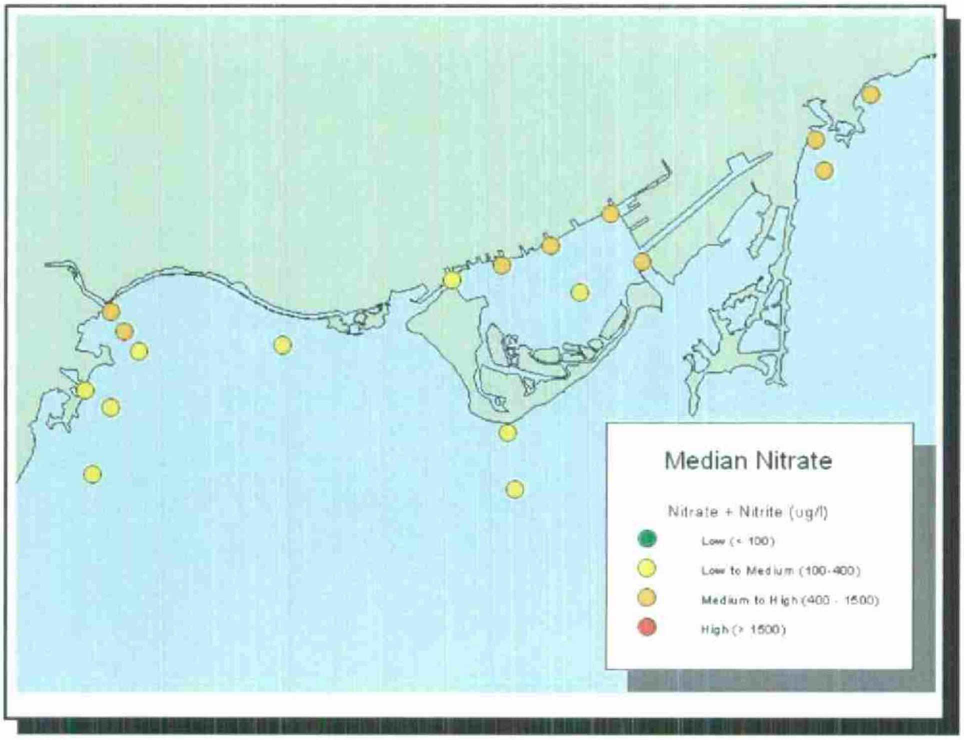

Figure 2.4.23a: Median Concentration of Nitrate at 1997 Toronto Waterfront Stations

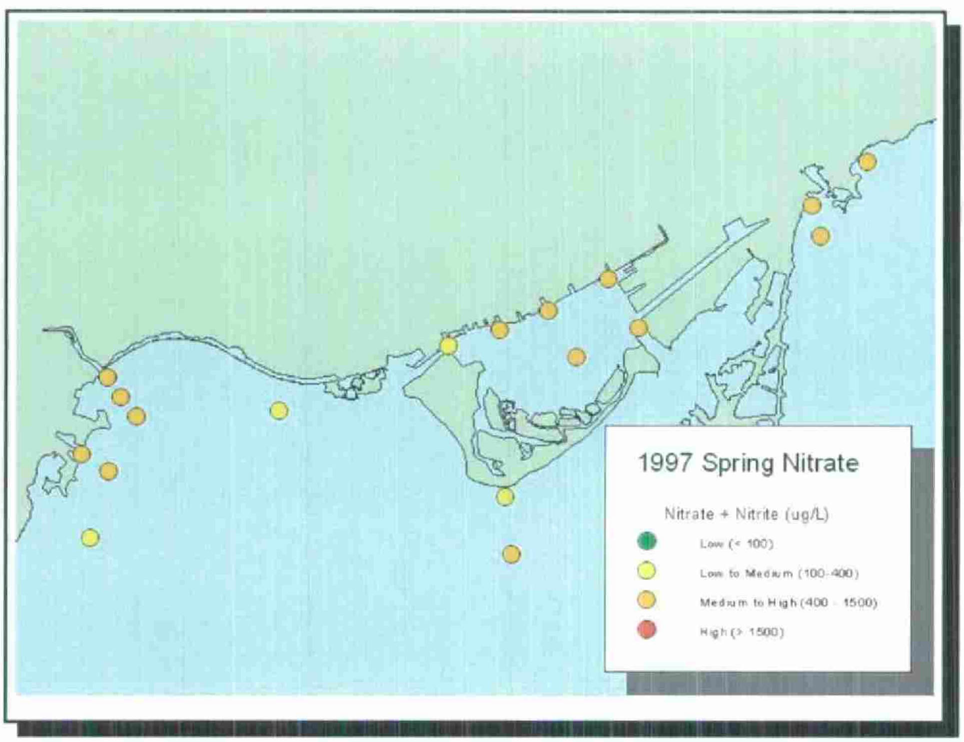

Figure 2.4.23b: Spring Concentration of Nitrate at 1997 Toronto Waterfront Stations

2.5 Lake Ontario Nearshore Sediment Quality Monitoring

Although the detection of trace metals and organics may be easier in sediment samples than water, discerning spatial and temporal trends, and the effects of pollution sources can be difficult in nearshore and harbour areas where sediment composition (and hence quality) can be patchy. It is possible for sediment to be resuspended and transported by storms and boat traffic so that conditions within a harbour can vary seasonally, obscuring inferences regarding year-to-year trends. In some areas patchiness can also be observed on a scale of less than one metre during a sediment survey. This local variability in sediment composition and quality has been illustrated by mapping selected results (particle size, PCBs, PAHs, and lead) from a Toronto Harbour sediment survey undertaken in 1995. Where available, equivalent data from a 1978 sediment survey have also been shown to demonstrate trends.

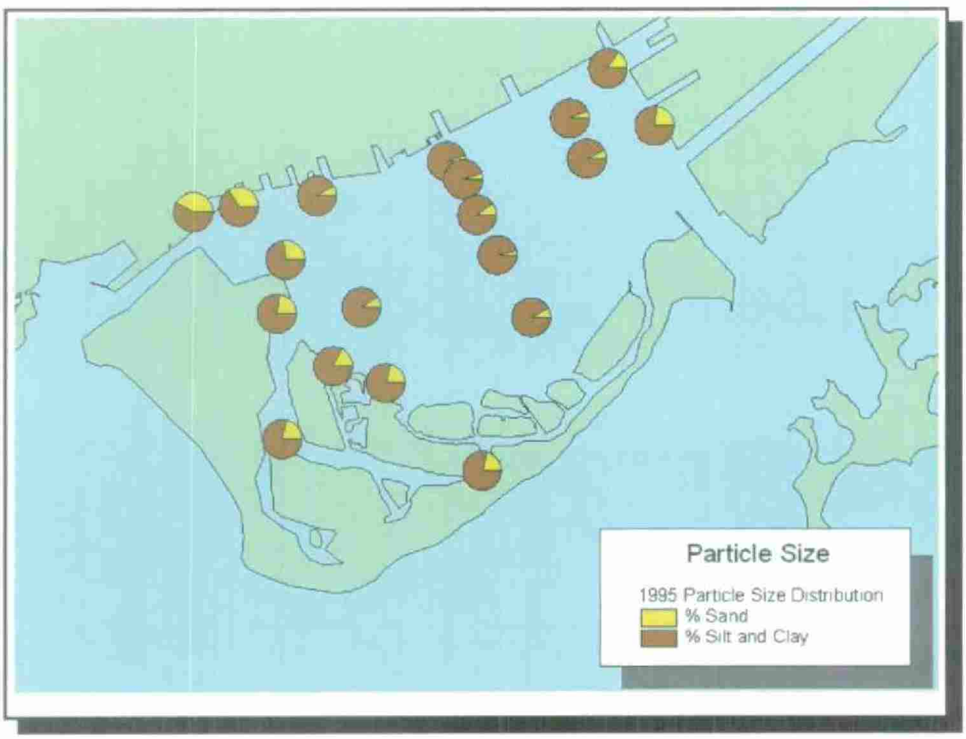

Figure 2.5.1: Variability in Sediment Particle Size Distribution at Toronto Harbour in 1995

Although the 1995 survey attempted to avoid sampling in sandy (energetic) areas and concentrated on depositional areas, there is still some variability in sediment composition (which will influence bulk sediment chemistry). As illustrated, PCB concentrations in sediment from the western harbour tend to have exceeded those in the eastern harbour, and comparison of 1978 and 1995 results shows similar maximum concentrations (although the location of the maximum concentration has shifted). Lead and PAH results both appear to have been influenced by urban runoff in the extreme northwestern portion of the harbour (near a large combined sewer overflow outfall and several storm sewer outfalls). Trend data are not available for PAHs, but lead results show a dramatic reduction in concentration largely attributable to the phasing out of lead as a fuel additive. The spatial pattern for lead has changed as well, with the northeastern portion of the harbour no longer exhibiting the elevated lead concentrations seen in the late 1970s.

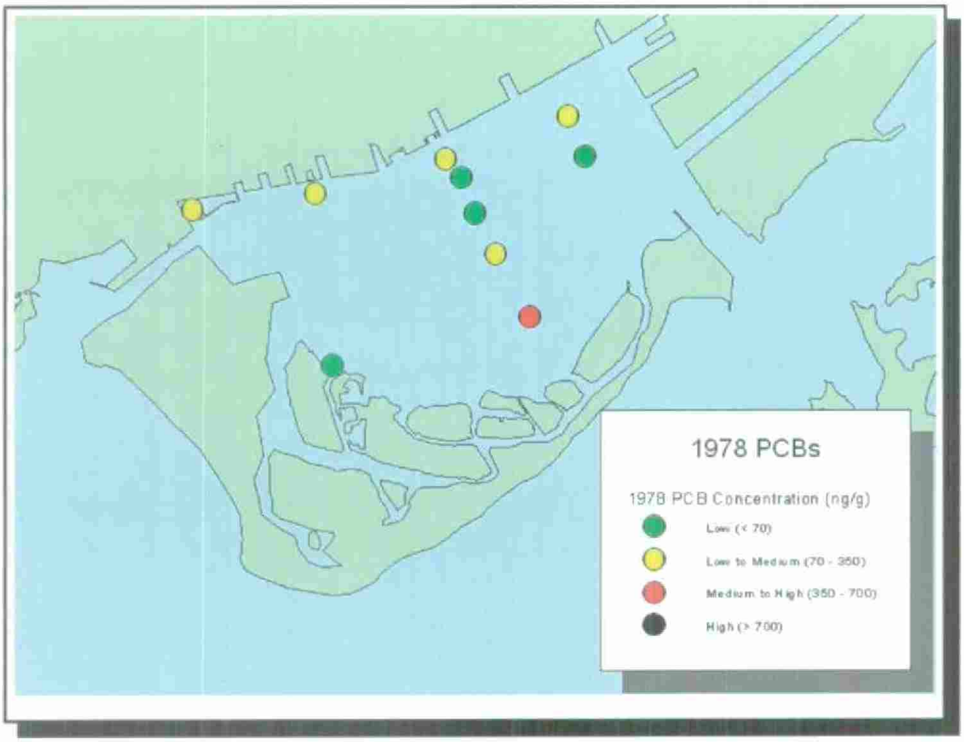

Figure 2.5.2: Variability in Concentrations of PCBs in Sediment at Toronto Harbour in 1978

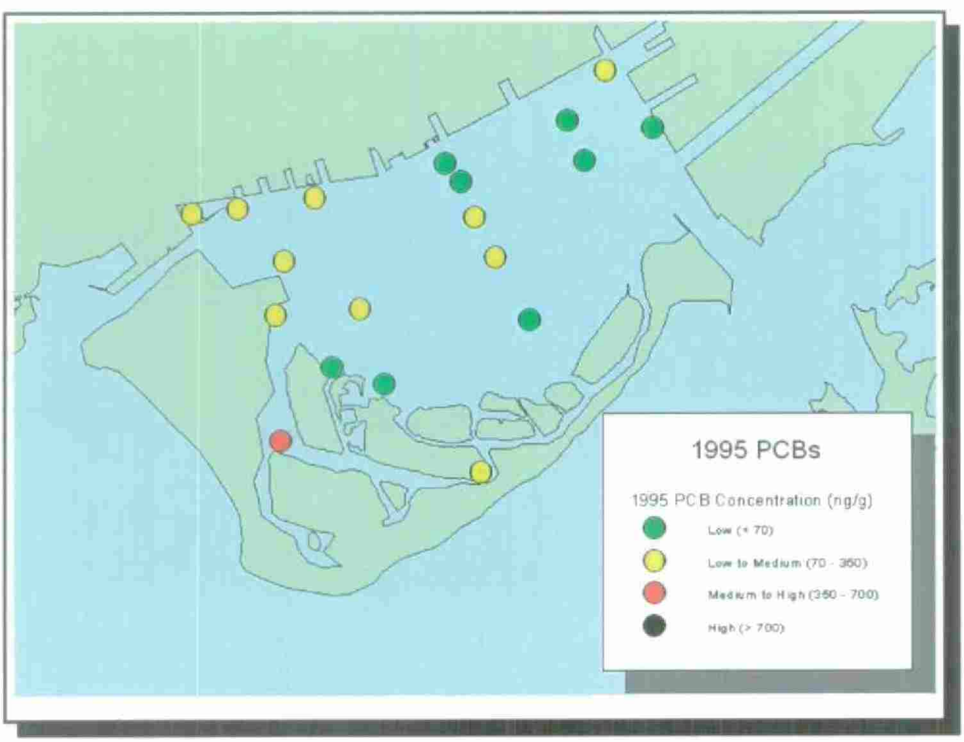

Figure 2.5.3: Variability in Concentrations of PCBs in Sediment at Toronto Harbour in 1995

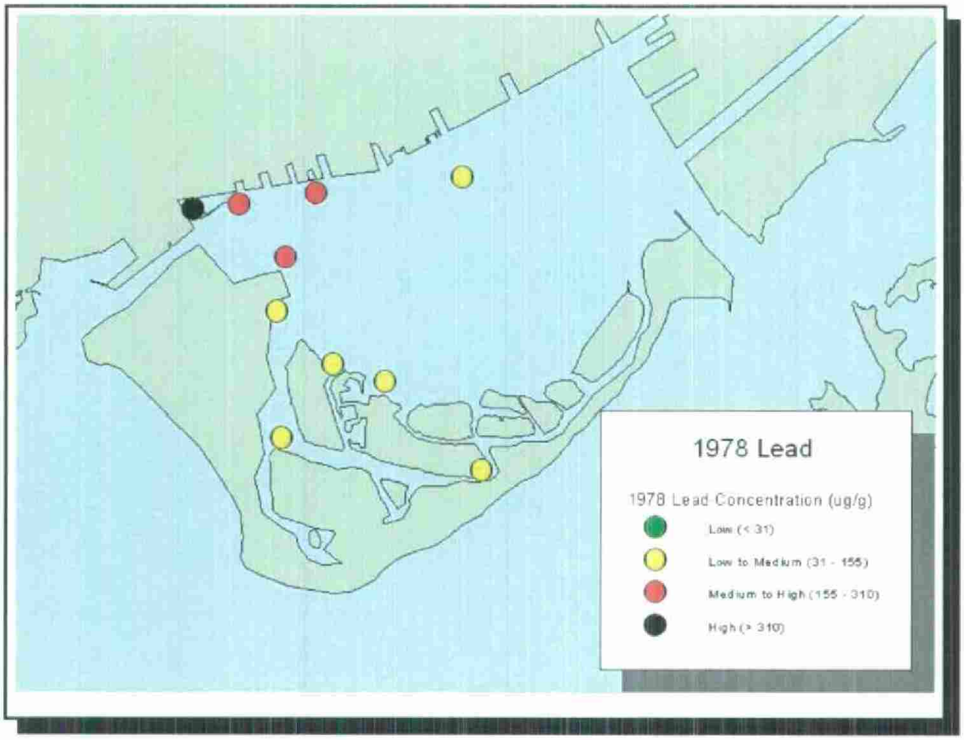

Figure 2.5.4: Variability in Concentrations of Lead in Sediment at Toronto Harbour in 1978

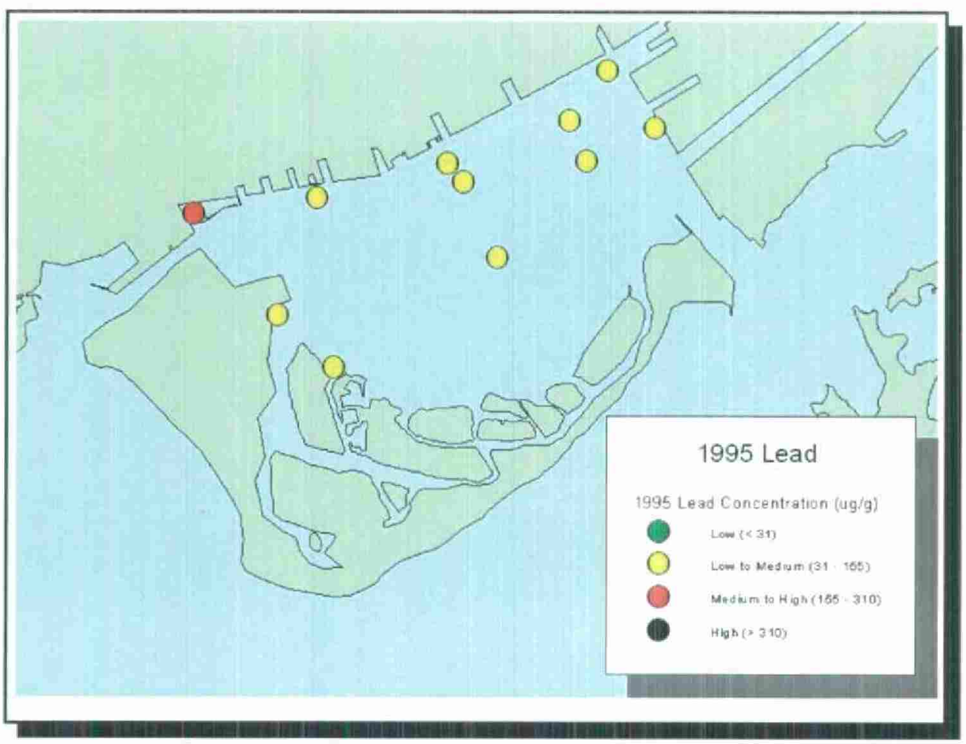

Figure 2.5.5: Variability in Concentrations of Lead in Sediment at Toronto Harbour in 1995

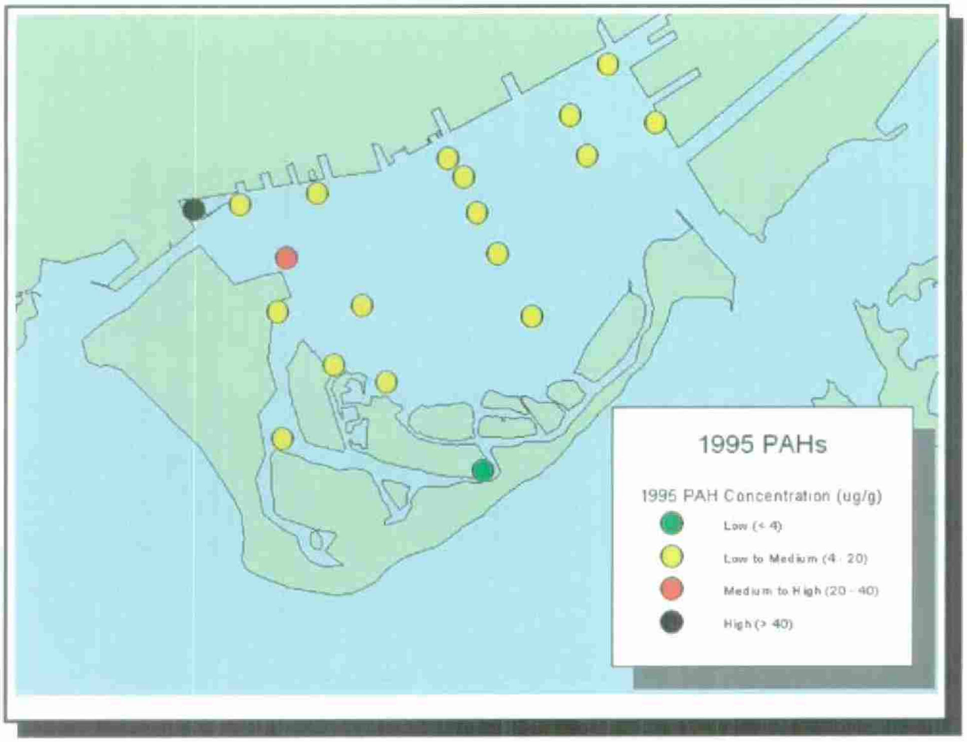

Figure 2.5.6: Variability in Concentrations of PAHs in Sediment at Toronto Harbour in 1995

The variability illustrated above means that it is extremely difficult to meaningfully characterize a nearshore zone by pooling contaminant concentrations for several locations. For this reason, the following maps use sediment quality data from Lake Ontario Reconnaissance Monitoring and Index Station Monitoring to compare maximum concentrations for selected indicators (PCBs, copper, lead, zinc) from one area to another. This provides a means of identifying the "hot spots" which occur around the lake as the result of proximity to current and historical sources.

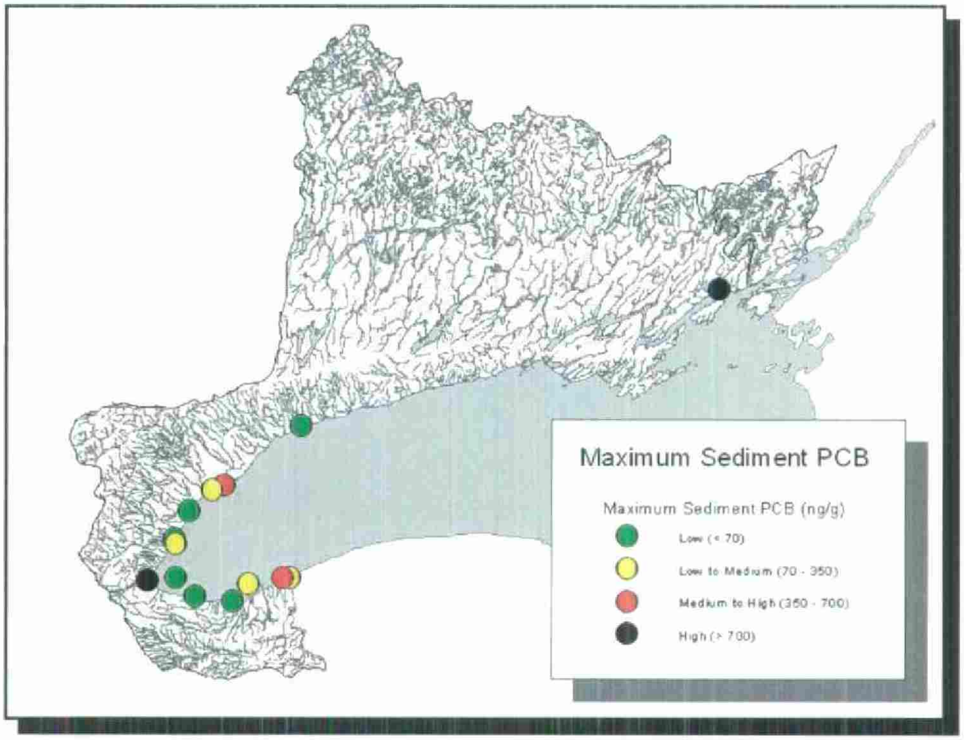

Figure 2.5.7: Maximum Concentrations of PCBs in Sediment at Lake Ontario Reconnaissance and Index Stations During the Period 1992 to 1997

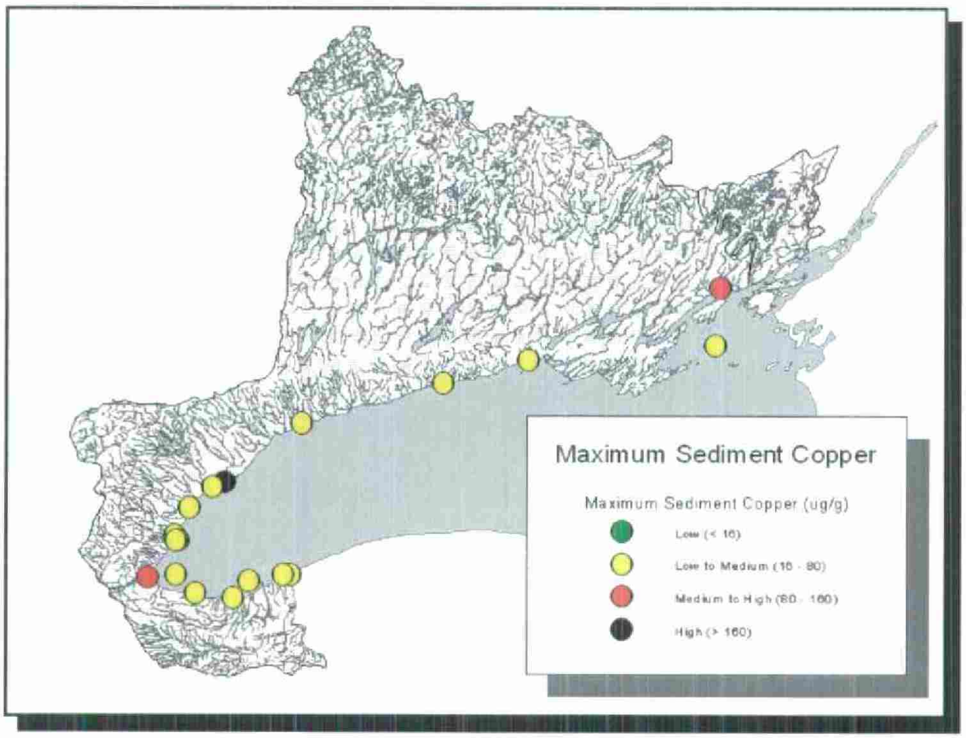

Figure 2.5.8: Maximum Concentrations of Copper in Sediment at Lake Ontario Reconnaissance and Index Stations During the Period 1992 to 1997

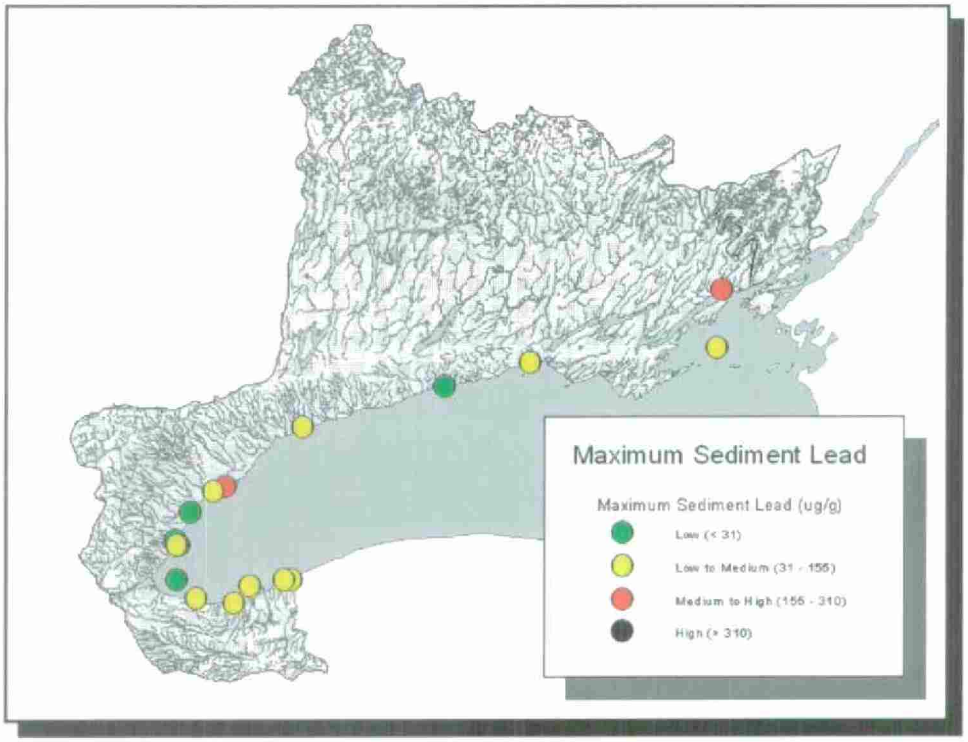

Figure 2.5.9: Maximum Concentrations of Lead in Sediment at Lake Ontario Reconnaissance and Index Stations During the Period 1992 to 1997

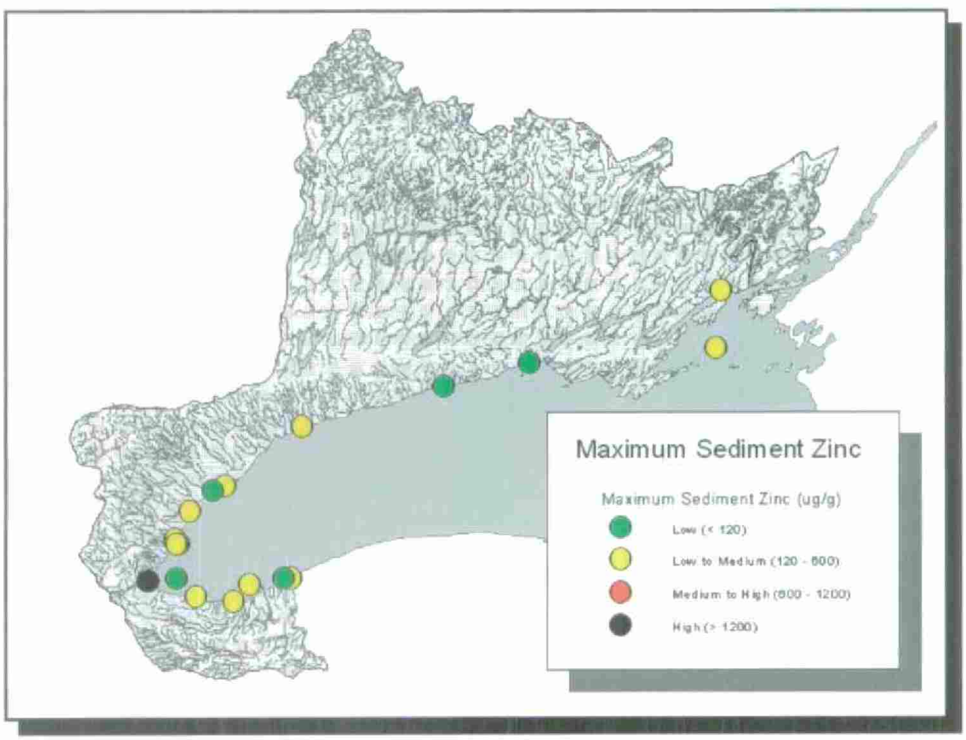

Figure 2.5.10 Maximum Concentrations of Zinc in Sediment at Lake Ontario Reconnaissance and Index Stations During the Period 1992 to 1997

Two locations have prominently elevated PCB peak concentrations when the data are mapped in this way: Kingston (down stream of the Belle Island waste site); and Hamilton (where historical accumulations of PCBs resulted in a Windermere Basin clean-up project in the late 1980s). Peak concentrations at Toronto Harbour and Port Dalhousie are also higher than other locations.

The highest peak concentration of copper is observable in Toronto Harbour sediment (from a sample obtained in the northwest corner near the combined and storm sewer outfalls). Elevated concentrations are also evident at Hamilton and Kingston. These same three cities, along with Port Hope, also exhibit elevated lead concentration compared with other sites. Zinc is relatively low everywhere except Hamilton Harbour where it is extremely high as the result of the local steelmaking operations. Interestingly, in this case sediment toxicity testing has shown that despite these extremely high concentrations of zinc, the age of the sediment means that the metal is in a form not readily available to biota and does not result in significant mortality.

2.6 Juvenile Fish Monitoring

As described previously, contaminants such as trace metals and organics have low solubility in water and tend to be adsorbed to sediment or accumulate in biological tissue. Trace organics such as PCBs and organochlorine pesticides (e.g. DDT, lindane, chlordane) are of concern due to their persistence and their potential to bioaccumulate through the food web into top predator fish and subsequently into fish-eating birds and mammals (including humans). For this reason, analysis of biological tissue is a useful means of augmenting water and sediment sample analysis. This has the advantage of determining an actual biological response to contaminant exposure, but is one step further removed from the contaminant source spatially and temporally. Monitoring for juvenile fish (typically young-of-the-year spottail shiners) is a good compromise in that their geographical range is limited relative to adult, top predator species, and the exposure period is known.

Results of sampling over the period 1990 to 1997 have been summarized for total PCBs and total DDT (i.e. the sum of DDT and metabolites) and median concentrations for each sampling area are presented to illustrate typical conditions around the lake. These results have also been compared with equivalent data for the period 1975 to 1980 at four locations to illustrate the general trend for western Lake Ontario.

These results show uniformly low DDT residues in juvenile fish around Lake Ontario, but demonstrate elevated concentrations of PCBs in fish from western Lake Ontario and the Toronto area. Despite the encouragingly large decline in DDT and PCB tissue residues between the late 1970s and mid 1990s (particularly at the Humber River and Toronto Inner Harbour), the International Joint Commission PCB guideline of 100 ng/g for the protection of fish-eating birds and mammals is not consistently being met.

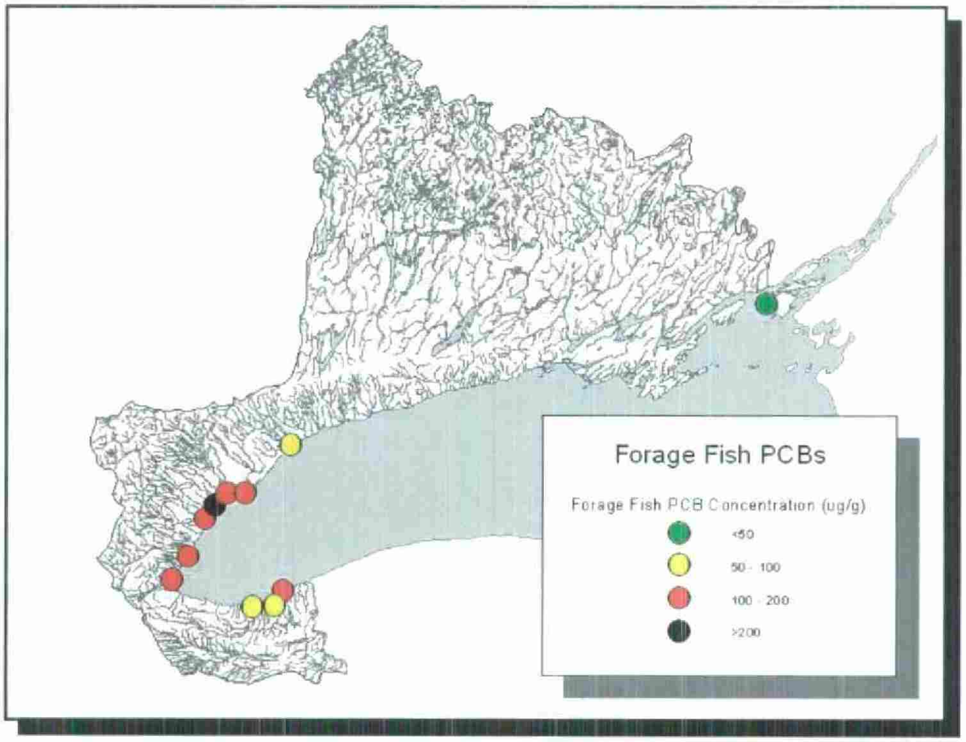

Figure 2.6.1: Median Concentration of PCBs in Spottail Shiners During the Period 1990 to 1997

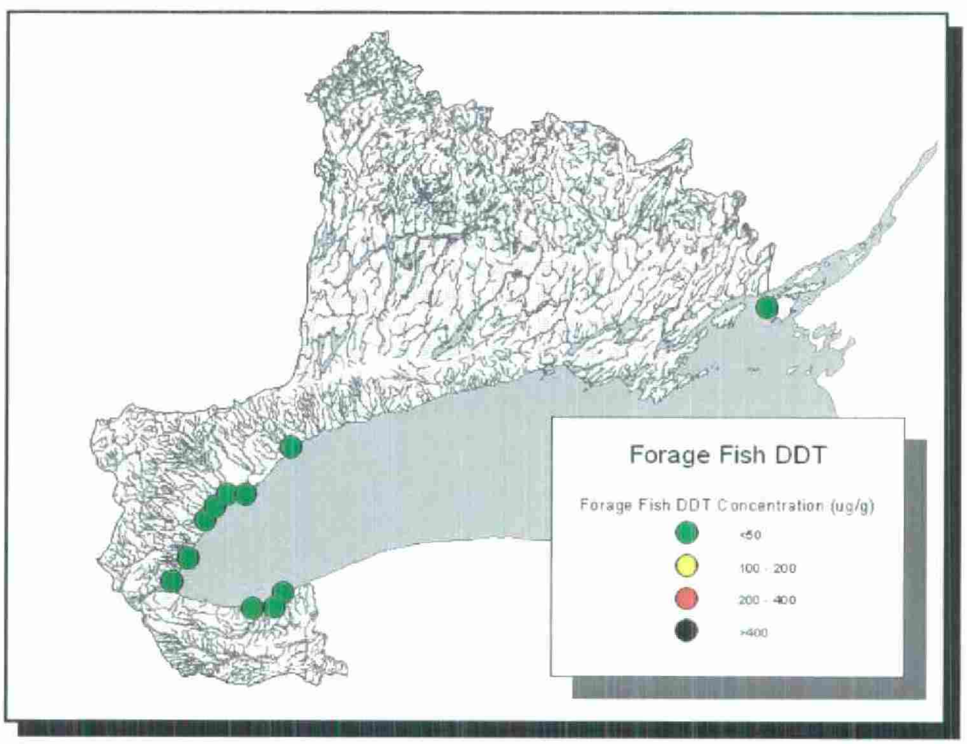

Figure 2.6.2: Median Concentration of DDT in Spottail Shiners During the Period 1990 to 1997

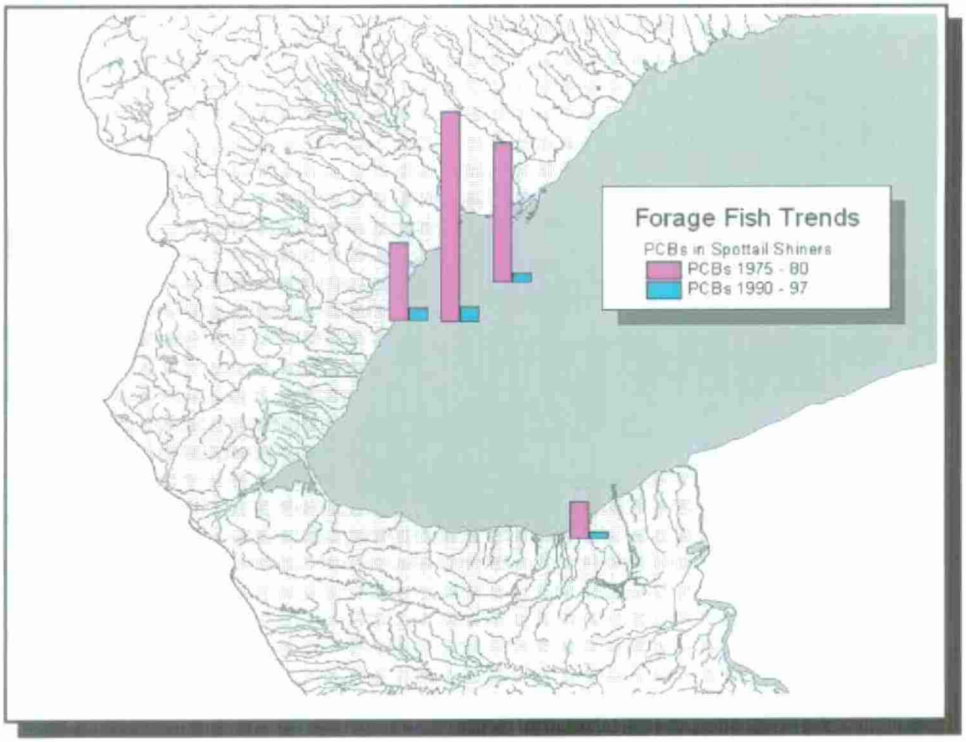

Figure 2.6.3: Comparison of Median PCBs Concentrations in Spottail Shiners in Western Lake Ontario between the period 1975 to 1980 and the period 1990 to 1997

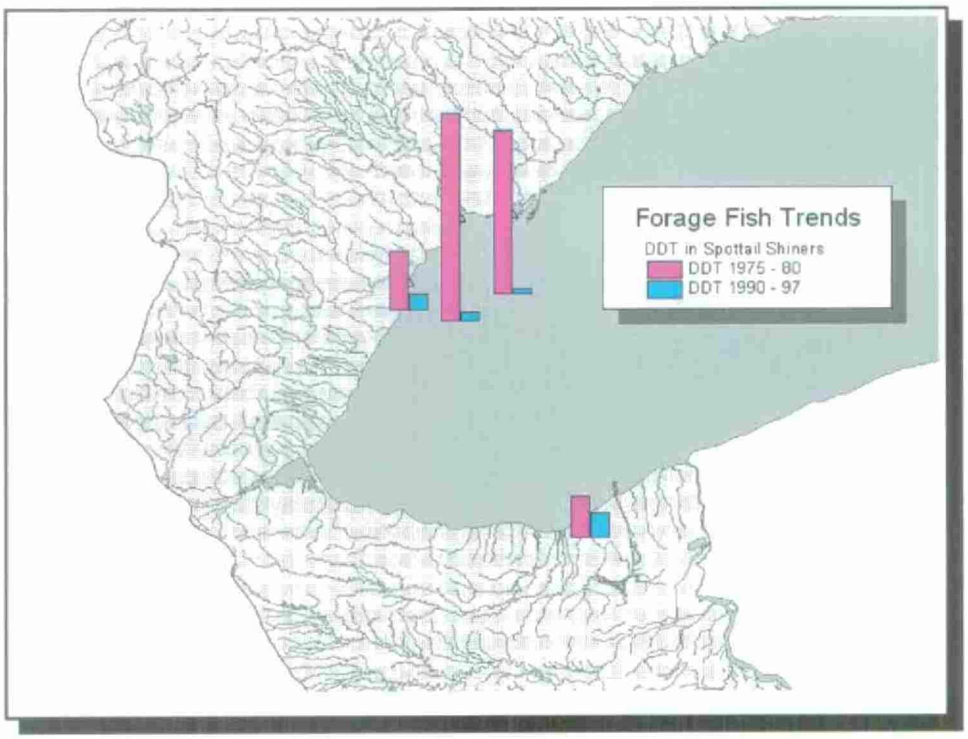

Figure 2.6.4: Comparison of Median DDT Concentrations in Spottail Shiners in Western Lake Ontario between the period 1975 to 1980 and the period 1990 to 1997

3.0 Summary

3.1 Water

< The pattern of chloride, turbidity, phosphorus and nitrate concentrations and trends in Lake Ontario watershed rivers and streams strongly reflects the geographical pattern of urbanization and population growth.

< The ubiquitous and persistent nature of PCBs is reflected in its routine detection above the current Provincial Water Quality Objective (PWQO) of 1 ng/L near tributary mouths around the Lake Ontario basin.

< Tributary mouth PAH, copper, and zinc data reflect land use, with median concentrations at Toronto area tributaries exceeding those seen elsewhere around the lake.

< With the exception of Toronto and Hamilton, which have a measurable medium-scale effect on the nearshore zone, chloride concentrations at index stations in Lake Ontario during 1994 and 1997 reflect open lake ambient conditions (principally influenced by flows from the Niagara River).

< Although turbidity results at Lake Ontario index stations vary both from site to site and year to year, Hamilton, Toronto and the Bay of Quinte (where eutrophication and increased algal productivity have historically been a problem) tend to have the lowest water clarity.

< Total phosphorus concentrations at index stations are fairly uniform around the lake and generally below the open lake guideline of 20 µg/L, except at Hamilton Harbour and the Bay of Quinte (in 1994). Increased nitrate concentrations are also evident at Hamilton Harbour.

< Generally oligotrophic (low nutrient) conditions now exist throughout the Lake Ontario nearshore zone outside of the Bay of Quinte and Toronto Harbour where mesotrophic (medium nutrient) conditions are now prevalent, and Hamilton Harbour where eutrophic (high nutrient) conditions remain.

< The pattern of Lake Ontario zebra mussel colonization in 1994 and 1997 reflects the introduction from Lake Erie via the Niagara River, and the subsequent transport by boat traffic to the eastern end of the lake.

< Chloride trends between the early 1980s and late 1990s in the nearshore zone of Lake Ontario show a slight decrease, despite the increase documented in Lake Ontario tributaries, since ambient conditions in Lake Ontario are largely influenced by flows from the Niagara River

< Phosphorus trends show an extremely large decrease over this period (despite increases in urbanization).

< Unlike phosphorus, nitrate concentrations have increased slightly.

3.2 Sediment

< Elevated concentrations of PCBs in sediment can be observed at Kingston and Hamilton. Sediment concentrations at Toronto Harbour and Port Dalhousie are also higher than at other locations.

< Enriched copper in sediment is observed at Toronto Harbour (in the northwest corner near combined and storm sewer outfalls), Hamilton, and Kingston relative to other locations.

< These same three cities, along with Port Hope, also have elevated lead concentrations in sediment compared with other sites.

< Zinc in sediment is observed at relatively low concentrations at Lake Ontario harbours except Hamilton Harbour where it is still seen at extremely high concentrations.

3.3 Biota

< Uniformly low DDT residues occur in juvenile fish around Lake Ontario.

< Elevated concentrations of PCBs are observed in fish from western Lake Ontario and the Toronto area.

< Although a large decline in DDT and PCB tissue residues can be observed between the late 1970s and mid 1990s (particularly at the Humber River and Toronto Inner Harbour), the International Joint Commission PCB guideline of 100 ng/g for the protection of fish eating birds and mammals is still not consistently being met.

Appendix A: Program Contacts for Additional Information

Program/Project	***Contact***	***'phone***	***email***
Provincial Water Quality Monitoring Network	Brian Whitehead	(416) 235-6256	whitehbr@ene.gov.on.ca
Streamflow Monitoring	"	"	"
Enhanced Tributary Monitoring	"	"	"
Great Lakes Index Station Monitoring	Todd Howell	(416) 235-6225	howellto@ene.gov.on.ca
Great Lakes Reconnaissance: Shoreline Mapping	"	"	"
Great Lakes Reconnaissance: Harbour Screening	Lisa Richman	(416) 235-6257	richmali@ene.gov.on.ca
Niagara River Toxics Biomonitoring	"	"	"
Great Lakes Tributary Toxics Monitoring	Mary Wilson	(416) 235-6238	wilsonma@ene.gov.on.ca
Great Lakes Water Intake Biomonitoring	Linda Nakamoto	(416) 235-5811	nakamoli@ene.gov.on.ca
Juvenile Fish Toxics Biomonitoring	Alan Hayton	(416) 235-5802	haytonal@ene.gov.on.ca
Investigations and External Services	Duncan Boyd or Wolfgang Scheider	(416) 235-6221 (416) 235-5810	boyddu@ene.gov.on.ca scheidwo@ene.gov.on.ca